REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1914-15

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
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(*Including the Report of the Imperial Cotton Specialist*)

1914-15.

REPORT OF THE DIRECTOR.

(Bernard Coventry, C.I.E.)

I. Charge and Staff.

Charge. I held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, and Mr. Wynne Sayer, B.A., of the office of Assistant to the Agricultural Adviser to the Government of India throughout the year.

Mr. A. C. Dobbs, B.A., who was the permanent Assistant to the Agricultural Adviser was transferred to Ranchi as Deputy Director of Agriculture under the Government of Bihar and Orissa on the 26th April 1915 and Mr. Sayer has been appointed to the post.

Staff. The Chemical Section was in charge of Mr. J. W. Leather, V.D., F.I.C., during the year.

Mr. Jatindra Nath Sen, M.A., Supernumerary Agricultural Chemist, has been posted at the Agricultural College at Sabour since September 1914 for research work.

Mr. A. Howard, C.I.E., M.A., held the office of the Imperial Economic Botanist during the whole year. Gabrielle L. C. Howard, M.A., has been appointed as Second Imperial Economic Botanist, from 10th February 1915. As in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1915 and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan.

Dr. E. J. Butler, M.B., the Imperial Mycologist, was on leave during the year. Mr. F. J. F. Shaw, B.Sc., Supernumerary Mycologist, who has been appointed to officiate as Imperial Mycologist was in charge of the Mycological Section.

Mr. T. Bainbrigge Fletcher, F.E.S., F.Z.S., held charge of the Entomological Section.

Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, was on deputation to the Punjab to carry out work on grain pests and cotton boll-worm till 27th April 1915 when his services were terminated on expiry of his probationary period.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section during the year except for the period from 30th August to 22nd September 1914, when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year. Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, has been appointed to the Indian Army Reserve of Officers. He left Pusa on the 4th June 1915 to join his duties in the Military Department.

Mr. A. C. Dobbs, B.A., remained in charge of the Agricultural Section till 25th April 1915 when Mr. S. Milligan, M.A., B.Sc., on return from leave resumed charge of the duties of the Imperial Agriculturist. The two posts of Supernumerary Agriculturists are now vacant, as Mr. Sayer has been appointed as Assistant to the Agricultural Adviser to the Government of India from 26th April 1915, and the services of Mr. G. D. Mehta, L.Ag., B.A., Supernumerary Agriculturist, who was posted to Madras for training, were terminated on 31st March 1915, on the expiry of his probationary period.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the period is indicated in the reports of the various sections.

Training. The post-graduate course students continued to receive training and short courses were also given in Sericulture and Lac culture.

The probationary research assistant under the Agricultural Chemist to the Punjab Government referred to in the last year's report completed his training in Agricultural Bacteriology during the year under report and the student deputed by the Department of Agriculture, Central Provinces, is under training in the same section. An assistant deputed by the Indian Tea Association is also under training in Agricultural Bacteriology.

In the Botanical Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture and a graduate of the Poona Agricultural College deputed by the Bombay Department of Agriculture completed their training in Botany during the year under report. The latter after finishing his course at this Institute has proceeded to England with a scholarship from the University of Bombay for further training in plant-breeding work.

A Fieldman deputed by the Principal, Agricultural College, Sabour, is undergoing training in Mycology in the Mycological Section.

In the Entomological Section an assistant deputed by the Punjab Government and a private student who is a graduate of the Lyallpur Agricultural College are under training in general Entomology.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. B. L. Gupta, Professor of Biology, Reid Christian College, Lucknow, referred to in the last year's report, completed his course in Mycology and left on 8th July 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona Agricultural College, worked in the Mycological Laboratory from 28th October to 5th November 1914.

Mr. Awati worked in the laboratory of the Pathological Entomologist for some time at the taxonomics of *Muscidæ*.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 14 Bulletins. Of these a fair number was contributed by the Provincial Departments. The memoirs continued to maintain their standard of excellence and were much in request from scientific institutions abroad. The bulletins containing matters more of practical than scientific interest continued to be in good demand particularly in India. They covered a large range of subjects such as sugarcane crushing, sugar machinery and manufacture, bee-keeping, improvement of indigo cultivation and sericulture. Among these bulletins four were contributed by the Provincial Departments and one containing notes on sugar machinery and manufacture in Northern India is a report by Mr. Peter Abel, an authority on the manufacture of sugar, who toured in this country with a view to advise the Government of India in connection with sugar matters generally. The grant for publications amounting to Rs. 29,000 has been made permanent. It has been decided to publish a revised edition of the Manual of More Deadly Forms of Cattle Disease in India. This useful manual was last revised in 1903, and opportunity has been taken to bring it up to date and to practically rewrite it. This will considerably add to its utility.

As in the last two years, strictest economy was exercised with the result that it was possible to keep down expenditure within the sanctioned grant. But as the superior staff of the Department capable of making original investigations is continually increasing, the volume of matter offered for publication will tend to increase when the present grant will be found inadequate.

IV. General Administration.

Buildings and Works. During the year under report the construction of two additional bungalows for European officers and the extension of the Pusa Library were completed. Additional quarters for the subordinate staff of the Institute are under construction. The schemes for the installation of electric lights and fans in the European bungalows and the Rest House at Pusa and for the addition of a female ward to the Pusa hospital as well as the proposal for a new ice machine at Pusa have been sanctioned.

Library. The third edition of the catalogue of the Pusa Library will shortly be out. During the year under report over 500 volumes were added by purchase besides many foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world.

Pusa Schools. The Middle English School was raised to the status of a High School on 2nd January 1915, and one of the long felt wants of the residents was thus satisfied. The number of pupils attending the school at the close of the year was 185. It has a staff of one Head Master and 14 Assistant Masters and promises success. A Lower Primary Girls' School was also started on 20th February 1915.

General Health of the Station. The general health of the station during the year under report continued to be good. Medical relief was afforded to 10,217 persons of whom 9,969 were treated in the out-patients' department and 248 admitted as indoor-patients. Ninety-one cases among the European officers and their families were attended to.

The daily average number of patients treated was 69·19 out-door and 12·14 in-door.

Ten deaths occurred in hospital, some of these cases were brought to the hospital in rather advanced stages of disease.

The epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of May and June, threatened to be a source of great danger. Immediate and successful measures were taken to prevent its entering the Estate, the chief of which was keeping of the water supply pure by disinfecting and cleaning of the wells.

One hundred and ninety-eight surgical operations were performed of which 27 cases were major and 171 minor.

Fourteen primary and four re-vaccinations were performed during the year.

V. Accounts.

The total expenditure during the financial year 1914-15 was Rs. 4,79,825 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,03,046
Chemical Section	41,807
Mycological Section	25,015
Entomological Section	43,142
Pathological Entomological Section	25,662
Botanical Section.	38,220
Bacteriological Section	31,592
Agricultural Section	71,341
Total	4,79,825

Out of the grant of Rs. 1,10,000 for the development of the Indian Sugar Industry referred to in previous year's report, a sum of Rs. 35,000 was provided in the budget for 1914-15 for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricul-

tural Adviser to the Government of India for special Agricultural Experiments were as follows :—

	Rs.
Purchase of two Ayrshire bulls for the Pusa Farm and the Agricultural Department, Central Provinces	1,920
Contribution to the Bacteriological Section .	1,030
Distribution of Pusa wheat seed No. 12 in the United Provinces	4,000
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . . .	1,500
Purchase of silk yarn for sericulture experiments at Pusa	240

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 16,843 as against Rs. 22,157 of the previous year.

VI. Visitors.

During the year under report His Highness the Maharaja Bahadur of Darbhanga, the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-Charge of Revenue and Agriculture, Government of India, the Hon'ble Mr. Lallubhai Samaldas, C.I.E., Member of the Legislative Council of the Government of Bombay and Mr. A. E. English, C.I.E., Registrar of Co-operative Societies, Burma, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. Milligan, M.A., B.Sc.)

I. Administration and Tours.

Mr. Dobbs continued in charge of the Agricultural Section until my return from combined leave on April 25th, 1915.

The number of the Supernumerary Staff has been reduced to *nil* owing to the termination of Mr. Mehta's agreement and the appointment of Mr. Sayer to the post of Assistant to the Agricultural Adviser.

Mr. McLean, Deputy Director of Agriculture, Bengal, and Mr. D. R. Sethi, Deputy Director of Agriculture, Bihar and Orissa, were posted to Pusa for preliminary training for periods of three and four months respectively.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. Mr. L. S. Joseph, Veterinary Assistant, acted for him in addition to his own duties for one month.

Mr. Md. Ikramuddin held the post of 1st Farm Overseer during the year. He was on privilege leave for three months from 2nd January to 31st March 1915.

Mr. Arjan Singh held the post of the 2nd Farm Overseer throughout the year and officiated for the 1st Farm Overseer for three months from 2nd January to 31st March 1915 in addition to his own duties.

Babu Brajaraj Mukerji, Fieldman, was promoted to the post of senior fieldman from 1st April 1915.

Mr. Imdad Hoossain Khan has been appointed as a Fieldman on Rs. 50—5—75 on probation for three months from 15th May 1915.

Mr. Dobbs visited Ranchi in October 1914 and the agricultural stations of Bengal, Bihar and Orissa, and the Central Provinces in December and January.

Mr. K. P. Roy from Bengal, attended the general course of instruction in Agriculture from 4th June to 16th September 1914.

II. Farm Cultivation.

Character of the season. The total rainfall of the season (June 1914 to May 1915) amounted to 54·88 inches. An abnormally heavy fall in August (28 inches) caused serious flooding in the lower lands and affected both the standing crops and the ensuing *rabi* crops.

Crop Experiments. The field experiments dealing with the maintenance of soil fertility under a double cropping system (*i.e.*, two crops per annum) by the use of manures, have been continued. The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in accordance with the experience gained. A large expansion of "quantitative" experimental work will not be possible for a few years until the land recently laid out for this purpose has been properly tested.

Cultivation. The Fowler's double engine tackle purchased in 1913 has proved its suitability to special circumstances with careful supervision. As was pointed out by Mr. Dobbs in last year's report Pusa Farm is far from being ideal for the use of such machinery and much better economic results could undoubtedly be obtained under more favourable conditions. The tackle is, however, of particular value at Pusa, with its large area under crop, in lightening the work of the supervising staff, and allowing of more concentration on experimental work and necessary improvements. The writer considers it premature to express any definite opinion as to the economic value of such tackle until correct figures can be worked out for depreciation and repairs which cannot be done while the machinery is new.

Trials of a new type of motor plough were undertaken for the makers. Some modifications of the engine to suit

the Indian climate have proved necessary and are being introduced.

III. Live-Stock.

Cattle Breeding. As mentioned in last year's annual report two herds are now being maintained at Pusa one of selected Sanhiwal (Montgomery) cows and their descendants, the other of cross-bred Ayrshire-Sanhiwal cattle.

As the breeding operations have since 1912 been based entirely on the milk records of the females the initial steps have been completed towards the building up of "milk pedigree" but results will not be apparent until the calves of the present generation have grown up.

The cross-breeding operations with imported bulls must be considered as purely experimental, the primary object being to gain information regarding the transmission of characters, valuable or otherwise, of the exotic breed.

Sheep Breeding. The operations as described in last year's report, *viz.*, the crossing of local sheep with Merinos with a view to gaining information regarding the inheritance of wool characters, have been continued. There is nothing to report as the second generation of cross-breds has not yet been produced.

IV. General.

Drainage. A new protective drainage scheme has been completed. The Pusa Estate has now been provided with its own outlet to the river and a pumping station has been erected to deal with excess water in times of high river levels.

The main drains of the low-lying area have been enlarged. New roads have been made to improve the shape of the fields and a new field added to the experimental area. Experiments in puddling rice land with steam disc harrows are in progress and arrangements have been made to control the irrigation and drainage of the rice area.

V. Programme of work for 1915-16.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.
2. The puddling of rice land by the double engine system of steam cultivation.
3. The combination of irrigation and drainage in the growing of rice.
4. A study of inheritance of the more important characters of dairy cattle by crossing.
5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.
7. Experimental tillage in the growing of maize and sugarcane.
8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. Walter Leather, V.D., F.I.C.)

I. Administration and Tours.

Charge. The section was in my charge during the whole year.

Establishment. Mr. Jatindranath Sen, the Supernumerary Agricultural Chemist, was posted to work at Sabour from September 1914.

Babu Surendra Lal Das Gupta, M.Sc., was appointed a probationary assistant on 6th February 1915 and he promises to prove a useful addition to the staff.

Babu Debendra Nath Chatterjee has been transferred to the office of the Chemical Examiner and Bacteriologist, United Provinces, from 7th June 1915.

Babu Mahabir Prasad was appointed a probationary assistant from 6th April 1915, but has reverted to the Education Department of the United Provinces.

Mr. G. K. Lele was dismissed in November 1914.

Tours. The following tours were made by me :—

1. September 1st to 9th. To Indore to advise as to the nature of the local soils.
2. September 12th to October 18th. Hill recess, when a memoir on Soil Temperatures was written.
3. November 4th to 20th. Tests of the freezing points of milks were made at the military dairies at Lucknow and Allahabad. I also attended the camp-of-exercise of the United Provinces Horse.
4. December 29th to January 10th. I visited Peshawar in order to test sugarcane at the time it was put into clamps.
5. March 13th to 28th. I visited Peshawar again to test the sugarcane when being taken out of the clamps.

II. Education.

No students have been admitted during the past year.

III. Meteorology.

In addition to the usual records for the Meteorological Department, records of (*a*) soil temperatures, (*b*) drainage, and (*c*) pressure by means of a barograph have been maintained.

IV. Soil Problems.

Soil temperatures. The temperature of the soil is well known to have an important influence on the soil, chemically and physically, but perhaps more especially on its biological activity, both with respect to the higher plant and lower organism. Moreover, since plant growth is principally confined to the upper two or three feet of soil, it is the temperature, and the temperature change, occurring in this stratum which is of importance. Several records of soil temperature have been maintained by the Meteorological and Survey Departments, but these have related rather to the temperature change of considerable depths than to that of the uppermost soil. For these reasons it was decided in 1910 to maintain such a record at Pusa. The soil being a bad conductor of heat, it is to be expected that the chief diurnal temperature changes will occur within the first few inches. It was then evident that for a record of soil temperature to be of service, it must relate to planes near to the soil surface. The nature of the soil-surface had also to be considered. Commonly this is rough, including lumps of earth varying from one to several inches in diameter with open spaces between them. How would such an irregular surface affect a thermometrical instrument ? A further primary question was what effect would a growing crop have on soil-temperature changes ? It was originally desired to ascertain the temperature changes for exposed soil (*a*) with a plain surface and (*b*) with a rough one, as well as for land bearing crops, but preliminary work showed that the diurnal variation in the first 3″ of soil was so great that an irregularity of 1″ caused

by the presence or absence of any odd piece of earth over the thermometer, would seriously impair the record; that indeed it would be necessary to know the distance from the surface to the instrument to within 0·1″ if the record was to be at all correct with reference to depth below the surface. For example, if two thermometers were placed at a nominal depth of 2″ below the surface, and owing to rough cultivation of the soil above them, the actual depth or thickness of soil were altered to 1·5″ and 2·5″ respectively, these two instruments instead of registering the same temperature, say at midday, would actually show a difference of more than 1° C. The rough cultivation commonly employed throughout India in the hot weather, which has been styled "hot weather weathering," implies a surface much more irregular than that just exemplified, and it was almost immediately clear that any record which was maintained below a roughly cultivated surface would be valueless because of the impossibility to define the distance from the surface to the instrument. The records maintained at Pusa have referred to the soil below (*i*) a smooth bare-fallow surface, and (*ii*) a similar surface on which crops were growing. The instruments employed were self-registering mercurial and alcohol thermometers of a good make, the errors being determined periodically. They were placed in tubes running horizontally below the soil surface at 1″, 2″, 3″, 6″, 9″, 12″, 18″, and 24″ deep. This arrangement is not what has been usual when observing soil temperatures, instruments being commonly inserted vertically into the soil. The latter is open to criticism in several respects; the instruments are exposed to the sun, they will generally possess a different, and often greater conductivity than the soil; the thermometer bulbs or sensitive part of a pyrometer indicates the mean temperature of the soil stratum in which it rests, and not that of a plain which is actually what is desired; if then the instrument is placed horizontally, this soil stratum is considerably thinner than if it is placed vertically in the soil, that is, this source of error is reduced.

The information has been published as a *Memoir of the Department of Agriculture in India* (*Chemical Series*, Vol. IV, No. 2) and the principal items of information are as follows :—

(*a*) *In bare-fallow soil.* (*i*) There are naturally both diurnal and seasonal changes of temperature. The former extends to between 1 ft. and 2 ft. from the surface; at 1 ft. deep it amounts about 1° C., but at 2 ft. it is doubtful whether it ever exceeds 0·1° C. in Bihar and probably never exceeds 0·2° C. in any part of India. Near the surface the diurnal change is very considerable. The seasonal change at 2 ft. deep amounts to about 13° C. The minimum temperature occurs in January and the maximum in May.

(*ii*) There is a fairly close correspondence between the soil temperature at 1″ deep, in bare-fallow soil, and the air (shade) temperature; approximately the soil-minimum is 2° higher and the soil-maximum 3° higher than the air temperature.

(*iii*) There is a similar relation between the *diurnal change* of temperature in the soil and air; at 1″ deep this change is about 1·5° C. greater in the soil than in the air. This diurnal change is least during the monsoon and greatest during the dry season, as is the case in the air. The amount of the change varies from 10° C. to 20° C.

(*iv*) Regarding the soil-temperature *at* the surface this could not be ascertained directly, but judging by collateral evidence, with a clear sky it probably rises to about 20° C. higher than the air (shade) maximum temperature during the day, and falls to approximately the air minimum at night.

(*v*) The above relations are substantially independent of season, and since the range of temperatures at Pusa is considerable, it seems reasonable to

conclude that they would apply to soils generally in India.

(*vi*) The temperature of the soil near the surface, (down to 3″ or 4″) is above the mean temperature for only about 8 hours and below it for about 16 hours.

(*vii*) The lag in temperature change is about 2 hours at 3″ deep and about 8 hours at 18″ deep.

(*viii*) A change in the specific heat and conductivity of the soil due to change of proportion of water, does not always affect the maxima and minima. During the monsoon period when the soil contains very much more water than during the dry season, and when both its specific heat and conductivity are consequently very much greater, the relation between soil temperature and air (shade) temperature remains substantially unaltered. That a wet soil requires considerably more heat to raise its temperature 1° C. than does a dry soil is of course well understood, but apparently the period of exposure is sufficiently great to allow the soil's temperature to assume during the day or the night the same relation to the air temperature whether it is wet or dry; the effect of increased conductivity counterbalancing that of increased specific heat. If, however, a heavy shower of rain falls on the desiccated soil of the hot weather, the conditions are different. Such showers are accompanied by a marked fall of air maximum temperature and the soil-maximum falls in a corresponding degree. But the air humidity at this season rapidly falls after such showers and evaporation of moisture from the soil increases very greatly, causing a marked change in the soil-minimum.

(*b*) *In cropped land.* The effect of a covering crop on the soil-temperature is naturally very marked,

for it both prevents the surface soil from rising to the temperature which fallow land assumes, and also modifies the diurnal change. Thus whilst the temperature of exposed soil at 1″ deep rises to about 3° C. *above* that of the air, that of cropped land is about 2° C. below it; and whilst the temperature of exposed soil *at the surface* rises to probably some 20° C. above that of the air, the corresponding figure for cropped land is only some 2° or 3° C. even in March, whilst in the rains it is actually lower than the air. Also in respect of diurnal change; at 1″ deep, whilst exposed soil suffers a change of some 20° C. in March, that of cropped land is only about 13° C. at the same depth; and during the monsoon whilst exposed soil suffers a diurnal change of some 10° C. at 1″ deep, that of cropped land is only about 3° to 4° C.

Soil gases. For some time attempts have been made at Pusa to devise an apparatus by the aid of which the gases contained in a portion of undisturbed soil, taken from a specified depth, might be extracted, measured and analysed. Hitherto the gases contained in soils have been separated for analysis by inserting a tube into the soil and aspirating a portion of gas out of it. By this latter method contamination with the outside air is possible, the real situation from which the gases flow into the tube is uncertain, and the direct measurement of the gas per unit volume of soil is impossible. But if a portion of undisturbed soil could be taken from the field in a tool which could be subsequently closed and provision made for attaching this to a pump, the volume of gas so obtained could be compared with the volume of the soil specimen taken from a specified depth and contamination with atmospheric air would be excluded. Although an apparatus for this purpose was designed several years ago and employed on some preliminary work on soil gases, it was not free from imperfec-

tions, and the more perfect one which has been employed for recent investigations was only designed and made in 1913. By its aid the gases contained in a known volume of soil taken from a specified depth below the surface can be separated, measured and analysed.

One of the first questions that occurs is whether a finely divided material like a soil condenses much gas on its surface. A volume of soil will include mineral and organic matter, water and gases. The volume of soil in the apparatus above referred to can be measured; the volumes of the solid material, and of the water can be derived from their weight and density, that of the gas which is extracted can be measured. Some of the latter will be in solution in the water, but the volume of this can be calculated. Thus these various measurements yield on the one hand the volume of the soil; on the other the volumes of solid material, water, gases. If there were no condensation of gas by the soil material, the sum of the latter would equal the volume of the soil *in situ*. But if the soil material is able to condense gases, the sum of the several constituents will exceed that of the soil. The measurements are naturally accompanied by some errors and it is not possible to say that the Pusa soil condenses no gas, but the proportion is certainly very small and is less than 4 per cent. of the total gas present.

The amount of gas which the water in the soil dissolves is of great interest. In dry land soils, the only gas which dissolves to any material extent is carbon dioxide, the volumes of dissolved oxygen and nitrogen being too small to be of any consequence. By the aid of the work[1] on the bicarbonates of calcium and magnesium which was done in this laboratory by myself and Mr. Sen, it is possible to calculate how much of the carbon dioxide is dissolved and in the gaseous state in the soil respectively. In fallow soil in all ordinary conditions very much the greater part of the carbon dioxide is in the dissolved state.

[1] *Mem. Dept. Agric. Ind.*, vol. I, no. 7, and vol. III, no. 8.

In the case of swamp paddy soil gases, the amount of dissolved oxygen and nitrogen has an important bearing. Messrs. Harrison and Subramania Aiyer have given reasons[1] for assuming that the dissolved oxygen is of importance both to the surface film and to the roots of the plant below. Calculations regarding the sources of the nitrogen in the gases have shown that probably about one-third of it is derived from the dissolved nitrogen of the irrigation water.

Regarding the examination of soil gases generally it is of importance not merely to ascertain the proportions of oxygen and carbon dioxide present. Although our knowledge of the biology of the soil is so imperfect, the general conclusion that oxygen is commonly used up in the production of carbon dioxide is no doubt justified, but the ordinary gas analysis might not show whether oxygen was being utilized in other ways. Again percentages of oxygen and nitrogen do not themselves show whether there has been an absorption of the one or an evolution of the other. For example supposing nitrogen gas were being liberated the effect would be an increased per cent. N, a decreased per cent. O; but these figures would not show whether oxygen was being absorbed by the soil or nitrogen liberated. An important case of this nature is the origin of the nitrogen in paddy land gases. Messrs. Harrison and Subramania Aiyer after discussing the matter[2] by means of indirect evidence, concluded that a part of the nitrogen in these gases was derived from the organic matters of the soil and manure, but a means of directly testing the question was clearly of importance. Such a question could be solved by the estimation of a gaseous element which takes no part in biological processes. The gases present in the soil are derived from (*i*) the outside atmosphere and (*ii*) the products of biochemical change. Hence if the nitrogen in the soil were derived solely from the atmosphere, its ratio to the rarer elements, argon, helium, etc., in the soil gases should be the same as in the atmosphere, whilst if nitrogen

[1] *Mem. Dept. Agric. Ind.*, vol. III, no. 3, p. 81.
[2] *Loc. cit.*, p. 82.

gas were being produced from organic matters or if it were being assimilated by a plant, its ratio to the rarer elements would be altered. The estimation of the proportion of argon in soil gases offered a probable solution of some of the above indicated questions. Argon takes no part in animal or vegetable economy, and except for very slight possible alterations due to diffusion, its ratio to oxygen and nitrogen in the soil would be the same as that in the air, unless these latter gases were absorbed or liberated during biochemical change. The atmosphere contains only 0·93 per cent. A against about 79 per cent. N, and since the accuracy of the estimation of the one depends on that of the other, the probable error in the ratio is not inconsiderable, but nevertheless as an aid to the examination of soil gases, the argon determination has proved of great use.

Mr. Harrison very kindly sent me samples of the gases obtained from paddy lands and the result of the analyses was to show quite conclusively that nitrogen gas is liberated in these lands from the organic matters. The N : A ratio in atmospheric air is 83, whilst those found in the paddy land gas varied from 92 to 98. Moreover it has to be realized that the outside air is so perfectly excluded that, apart from any nitrogen evolution in the soil, the nitrogen and argon in these gases are largely derived from the dissolved gases in the water, in which the N : A ratio is 33. Hence the conclusion was admissible that a high proportion of the nitrogen in these gases is derived from the decomposition of the organic matters.

In other cases the N : A ratio has not proved so serviceable as was at first hoped. The assimilation of nitrogen gas by *Papilionaceæ* is a case in point. It is usually assumed that the assimilation, by these plants of a part of their nitrogen is effected indirectly by the agency of the bacterium, *Bac. radicicola* in the root nodules, but the assumption lacks direct experimental proof. Allowing the truth of the assumption, then the N : A ratio would fall in the gases present in the neighbourhood of the roots of such plants. As a matter of fact nearly all the N : A ratios

found for samples of such gases were low, but unfortunately it is not possible to determine this ratio very precisely, and the difference actually found had to be referred to probable error. In addition, subsequent considerations of the quantities of nitrogen involved indicated that it is doubtful if the question of the assimilation of this element by the roots of *Papilionaceæ* can be solved by the N : A ratio.

Another question naturally arises, namely, whether other gases than carbon dioxide or nitrogen are produced in soils ? The gases of swamp rice-land include much hydrogen and methane, but the conditions are anaerobic and the general opinion has been that in ordinary dry-land soils such gases would not be produced. For example recent samples of gases from Rothamsted soils[1] were found to be free, or substantially free, from hydrogen and hydrocarbons. In some of the Pusa soil gases small, though well defined, amounts of hydrogen were present. This was the case particularly in the neighbourhood of the roots of crops, san hemp, indigo, maize, and must be referred to bacterial activity. In the same situations very large proportions, 16 to 20 per cent., of carbon dioxide, and low proportions—2 to 4 per cent.—of oxygen were found. Such proportions of these gases have not been met with elsewhere in the neighbourhood of crops, but it is to be recollected that the subject is one which has been hardly investigated hitherto and indicates a very intensive activity of lower organisms at least during the monsoon in India.

The conditions during a period of rapid nitrate formation are again very interesting. When discussing the drainage of rain water through soils, [2] evidence was adduced showing that intensive nitrification in the first few inches of soil followed immediately after the first heavy rain of the monsoon, in 1910; this occurred similarly in 1911 and 1914. During this process considerable amounts of oxygen are required, and calculation showed that this

[1] *Jour. Agric. Sci.*, VII, 4.
[2] *Mem. Dept. Agric. Ind., Chemical Series*, vol. II, no. 2.

oxygen could hardly be accounted for by that which was present in the soil. Other experiments showed that this soil utilizes under such conditions even much more oxygen than that required for the nitrate formation. On the other hand analyses of the gases in 1914 showed that despite the large amount of oxygen required, the percentage of this element in the soil was nearly normal. It became evident therefore that a sufficient supply of oxygen must have been diffusing into the soil from the atmosphere.

The process of diffusion of gases through soils has been generally believed to be a very slow one. Direct experimental evidence on the subject is limited to that of E. Buckingham [1] who concluded that there was a direct relation between the " porosity " of a soil and the rate at which gases could diffuse through it. The " porosity " he defined as that fraction of the whole volume of soil which is occupied by gases. He defined any particular portion of soil as unity and the " porosity " is therefore less than unity. Soils commonly include as gas some 20 to 40 per cent. of their volume, and the " porosity " in such cases varies from 0·2 to 0·4. Buckingham considered that the equation :

$$D = K S^2$$

was sufficiently accurate to define the quantity of a gas diffusing through a known column, (or depth) of soil, under known gradient; and that this quantity is less than would diffuse if no soil were present by the square of the porosity. The results of such experimental work should, if possible, be checked by independent evidence, but the difficulty is to provide such independent evidence.

Buckingham's equation was applied to several of the cases which have formed the subject of the work on soil gases at Pusa, and in some respects at least it is supported. For example where green manure was applied during the monsoon, the calculation showed that 0·0658 c. dm. of CO_2 was leaving the soil per sq. dm. per day during the first 10

[1] Contributions to our knowledge of the aeration of soils by E. Buckingham; *U. S. Dept. Agri. Bur. soils, Bull.* no. 25, Washington, 1904.

days. Assuming a uniform rate of decomposition, the whole of the green manure would be oxidized in about 95 days. There is, however, reason to suppose that the rate would fall off as time went on, so that as an independent test of the reliability of the equation, it may be considered to support it very well. Again the calculated amount of carbon dioxide production in soils in which nitrification was in progress agreed very fairly with what was experimentally determined under controlled conditions in the laboratory. On the other hand calculations for the volumes of oxygen diffusing into the soil yielded unexpectedly high figures. One cannot go further with the matter at present, but it is at least certain that the process is a much more rapid one than is commonly supposed.

The value of good cultivation of the surface soil has been usually attributed to the fact that by stirring the soil, gaseous interchange is suitably accelerated, carbon dioxide is allowed to escape and oxygen to enter. It is often easy to suggest an explanation which on paper bears the necessary "hall-mark," but it is somewhat remarkable that among the many who have accepted this explanation for the advantage of good cultivation, none appears to have considered that much deeper stratum of soil—several feet in thickness—which is never disturbed by cultivating implements but in which crop roots develop freely and which it is equally necessary to aerate. If for efficient gaseous interchange it is necessary to plough the top 6″, it should be similarly necessary to plough the succeeding several feet of soil! So long as one is content to accept the proved value of good cultivation without attempting to give explanations for its advantage, the position is unassailable; but if one goes further and states that the explanation is that thereby objectionable carbonic acid is released from or valuable oxygen admitted into the soil, the premises are very readily open to criticism. Even allowing Buckingham's experimental work to have been a good deal in error, the consideration of the cases which have been examined at Pusa shows that, so far as aeration is concerned, the culti-

vation of the surface soil might be omitted altogether; its well established value must be referred to other causes.

A memoir on the subject is now in the press.

V. Manures.

Village ashes. Owing to the war the supply of potash salts from Stassfurt has ceased and since these mines have formed the chief source of the world's potash supply for a number of decades, the price of all potash salts has risen seriously.

India is not a large consumer of potash salts, but there is a small steady demand for such among the tea and coffee planters of Southern India, and it was thought to be worth while to examine samples of village ashes obtained from the several provinces in order to ascertain whether potash could be economically extracted from them. Seventeen samples were examined and the percentage of potash varied from about 1 to 10 per cent. From one quarter to two-thirds of this is frequently soluble in water. The remainder could be extracted by the agency of strong acid, but this could not possibly pay. The water soluble potash could be readily and very cheaply extracted in a manner similar to that employed for the extraction of saltpetre from earths. The evaporation of the water, in order to obtain the crude potash salt, would require relatively a good deal more fuel than is required for the evaporation of the crude saltpetre liquors, and since the crude potash salts obtained per 100 lb. of water evaporated would not be worth nearly as much as the corresponding quantity of crude saltpetre, and since also the latter operation hardly pays the *nuniah* to continue his industry, I concluded that it is very doubtful if the manufacture of crude potash salt from village ashes could succeed.

It seems probable that tea and coffee planters who require potash salts could most readily supply the present deficiency by either burning waste timber on their own estates or by doing so in the nearest forest, and putting the wood ashes direct on the land, or possibly after first

treating the ashes with a limited amount of sulphuric acid. A note has been submitted on this subject.[1]

VI. Saltpetre.

The experiments on the improvement in methods for refining saltpetre have progressed considerably during the past year and there is now every reason to hope that by the use of a filter press and other appliances the outturn of refined saltpetre will be considerably greater than is usually obtained by refiners.

VII. Feeding Stuffs.

A considerable number of specimens of cattle foods have been analysed during the year more particularly on behalf of the military authorities. It is intended to issue these and other analyses shortly in the form of a bulletin.

VIII. Sugar.

Sugarcane. The nature of the sugar investigations which have been in progress during the past three years at Tarnab, Peshawar, was explained at length in my last annual report. The only additional work which has been done during the past year consisted in a test, on a large scale, of the safety of "clamping" large quantities of sugarcane. It will be recollected that from the manufacturing point of view the advantage of being possibly able to preserve sugarcane over the months of February to April was recognized and experiments with small lots of sugarcane were made during the cold weather of 1913-14. These indicated that the local sugarcane could be so preserved until at least sometime in March without suffering serious depreciation. It had to be recognized, however, that in order to draw a safe deduction the tests should be made with large quantities of cane such as would probably occur in practice, because the conditions in small heaps would be different in some respects; the weight of cane in a large heap would subject the cane at the bottom to a greater

[1] *Indian Trade Jour.* July 23rd, 1915.

pressure than would occur in a small heap; the care which could be economically devoted to the handling of a large quantity of cane might not be sufficient to prevent considerable breakage of cane, resulting in a possibly serious amount of rotting; it was also desirable to estimate the cost of clamping.

Accordingly Mr. Robertson Brown arranged to calmp two lots of sugarcane in January, the one from approximately an acre and weighing about 20 tons, the other from half an acre and weighing about 16 tons. The former was "striped Mauritius," the latter "local *pounda*" cane. These two lots of cane were put into the clamps during the 1st week of January and the clamps were opened and tested during the third week of March, that is after a period of about 10 weeks. In the following table the chief data are set out, from which it will be seen that the amount of change suffered by the cane was nominal.

	Striped Mauritius		Local *pounda*	
	January	March	January	March
Weight per cane (lb.)	1·74	1·79	1·78	1·91
Juice per cent.	71·6	65·7	73·1	71·1
Sucrose (per 100 parts of juice.)	13·19	12·11	12·34	11·20
Invert sugar (per 100 parts of juice.)	0·83	0·73	1·29	1·04
Brix	16·1	14·8	15·3	14·5
Co-efficient of purity	84·7	84·6	83·6	81·5

These two experiments leave no doubt that sugarcane can be safely preserved in clamps until the end of March at Peshawar without suffering any serious loss. The number of canes which rotted in the clamp was very small; rotting was quite definitely restricted to cane which had been accidentally cut or broken and did not extend beyond the originally damaged part, nor did it spread to sound cane. No sound cane was damaged at all.

Mr. Robertson Brown and the writer have discussed the practicability of employing this process on the large scale for the advantage of a factory. There is no doubt that it is rather more troublesome to take cane up by the roots than to cut it off; there is also the cost of putting the cane into clamps, and the cost of taking it out again. Altogether apparently this increased cost would come to about one anna per maund of cane. On the other hand it is to be realized that a factory situated in this part of India could certainly afford to pay somewhat more for cane in February and March rather than stop working altogether, for in the latter event the whole of the more expensive staff is kept idle and the daily paid labour becomes dispersed. It is therefore by no means necessarily the case that because it costs something to put cane into clamps, it would not pay everyone concerned to employ the process.

Estimates were obtained during the year for a small sugar factory fitted for working beet and cane and capable of producing from 1 to 2 tons of sugar per day. These were submitted to the Agricultural Officer, North-West Frontier Province. Briefly the factory would cost about Rs. 1,50,000 erected; the annual running charges would come to :—

	Rs.
Wages, etc.	10,000
Cost of 900 tons of cane . . .	9,150
Cost of 900 tons of beet	10,800
	29,950

whilst the value of sugar produced (155 tons) would be about Rs. 33,480. The total sugar annually imported into the North-West Frontier Province is about 9,000 tons which is either consumed locally or re-exported to other frontier countries. Some of this sugar could be easily grown and manufactured locally without in any way seriously affecting the local production of *gur*, which is considerably greater, namely, about 35,000 tons.

Cocoa-nut "milk." At the request of the Chief Commissioner of the Andamans and Nicobar Islands the milk of cocoa-nuts was examined with a view to ascertaining whether it possesses potential commercial possibilities. About twelve lakhs of nuts are utilized annually in the Jail, but for the milk there is no commercial outlet and it is thrown away. It is only a weak solution of sugars and other carbohydrates with small amounts of proteids. The sample sent to Pusa contained 0·187lb. sucrose, 0·056lb. glucose and 0·258lb. of other matters, mostly gums, per gallon of the milk. Boiled down to the dry state it formed a very pleasant tasting "toffee," but it could not possibly pay to conduct this process on the manufacturing scale.

IX. Starch.

During the year my attention has been directed to the possibility of economically manufacturing starch from Indian materials. One of the results of the war has been to cut off some of the usual sources of manufactured starch, resulting in enhanced prices.

The process involved in starch manufacture is extremely simple, but in order to be financially successful the raw material must be cheap and the factory machinery both efficient and well run. This implies expensive management which can only be economically applied for large quantities of starch.

Among Indian raw materials which could possibly fulfil the requirements of the industry, is the sweet potato, (*Ipomoea batatas*,) which is cultivated widely in Bihar, yields well per acre at small cost, comes into the market at several different seasons and some varieties contain upwards of 20 per cent. starch. Experiments have therefore been commenced on the subject of starch manufacture generally and primarily from this material in particular. A very good quality of "farina" can be readily prepared from it.

X. Milk.

Detection of added water in milk. The value of the freezing point of milk as a means of detecting added water was referred to in my last annual report. It was there explained that the value of the test could only be given serious weight after determining the freezing point of a considerable number of milks of known purity, and if the variation were then found to be sufficiently small.

I took the opportunity when on tour to apply the test to a further number of milks at dairy farms, and although the variation of freezing point among milks of Indian cattle is greater than has been found elsewhere, there is no doubt that it forms a much more delicate test for added water than those hitherto employed. It is proposed to publish a note on the subject shortly.

XI. Programme of work for 1915-16.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops are maintained.

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. The relation between the transpiration of water by plants and the assimilation of plant material during the period of growth will be examined.

4. An examination of the proportion of starch in some of the Indian starch producing crops will be made and their possible utility from the manufacturing standpoint will be considered.

Minor subjects :—

None.

XII. Publications.

1. Indian Village Ashes as a Source of Crude Potash Salts, by J. Walter Leather. *The Indian Trade Journal, xxxviii, p. 132.*

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., M.A. and Gabrielle L. C. Howard, M.A.).

I. Introduction.

The Imperial Economic Botanist held charge of the section during the year under review. On February 10th, 1915, the Personal Assistant was promoted by the Secretary of State, on the recommendation of the Government of India, to the post of Second Imperial Economic Botanist.

The work of the staff continues to be satisfactory. The post of Fourth Assistant was filled by the appointment of Chowdhri Ram Dhan Singh, who was confirmed after twelve months' service as a probationer. The good work of the Second Assistant, Maulvi Abdur Rahman Khan, was rewarded during the year by a substantial increase in pay. At Quetta, Overseer Chandu Lall has made satisfactory progress.

Two advanced students, from Bombay and Bengal respectively, worked for a session in the section. The former then proceeded to England, having obtained a scholarship for three years for plant-breeding work; the latter has been recommended for trial in the Bengal Agricultural Department as a probationer.

II. Investigations at Pusa.

Wheat. *Pusa 12.* In the last report, a detailed account was given of the successful trials by cultivators of Pusa 12 in the chief wheat-growing provinces of India and of the initial steps contemplated in the establishment, on a commercial scale, of an improved grade of white wheat. During the year under review, considerable progress has

been made in both these directions and important results have been obtained.

In connection with the trials of Pusa 12 by the ryots in the various wheat-growing areas, the results obtained in the United Provinces are perhaps the most important. The season in these provinces was not a very favourable one for wheat. The rains ceased early and, in many Districts, the crop had to be sown in too warm a seed-bed. The winter rains were late and although there was a marked improvement in February, this was speedily followed by long continued wet weather which brought on rust and seriously diminished the yield. Under these adverse conditions, Pusa 12 did well and stood out conspicuously from the country wheats. The general results are thus summed up by the Director of Agriculture in " United Provinces Agricultural Notes for March, 1915 " which appeared in the *Pioneer* of April 11th last.

" Pusa No. 12 wheat, of which a considerable area is now grown over different parts of the Provinces, has done well everywhere. It has shown itself relatively rust-resisting, and has given a good yield even in the worst affected districts. This feature has attracted particular attention in a year like the present, and there is little doubt about its rapid spread in future."

In the previous wheat year, 1913-14, a season of short moisture, Pusa 12 did much better than the country wheats as it was able to ripen a good crop with comparatively little moisture. Shortness of moisture during the growth period, the early cessation of the rains (leading to a warm seed-bed and subsequent liability of the seedlings to wither and to be destroyed by white ants) and long continued wet weather after the crop comes into ear (giving rise to serious attacks of rust) are the chief factors which limit the yield of wheat in the Gangetic alluvium. From the point of view of the testing of a new variety in this tract, the two seasons, 1913-14 and 1914-15, have been very favourable ones as, in both cases, adverse factors have been experienced. In both years, Pusa 12 has shown a

marked superiority over the local wheats and these facts must be regarded as of the greatest promise for the future of this variety.

During the year, the best yield of Pusa 12 so far reported was that obtained by Mr. Clarke at the new Sugarcane Experiment Station at Shahjahanpur, where over 500 maunds of seed were obtained from an area of $16\frac{1}{2}$ acres, although a portion of this was badly lodged by rain and wind just after the crop came into ear. This outturn is over 30 maunds or 40 bushels an acre. Very good returns were also obtained on the private farms of the Taluqdars of Oudh as well as in other parts of the Provinces. The results clearly show that it is possible to produce in India wheats which combine both high yield and good quality when grown by the people themselves.

Progress has been made in the work relating to the shipment of Pusa 12 for trial by the Millers of the United Kingdom. This side of the work is being carried out in the Central Circle of the United Provinces with the co-operation of Mr. B. C. Burt, Deputy Director of Agriculture, who is working to replace the country wheats by Pusa 12 from certain centres near Cawnpore. The surplus will be bought up by Government and shipped by Messrs. Ralli Brothers who, with Mr. Humphries, have undertaken to bring this wheat to the notice of the Home Millers so that they may have an opportunity of getting first hand experience of its qualities and behaviour. In the District work, the Co-operative Credit movement has been utilized as well as Court of Wards' estates and large *zamindars*. In spite of the shortness of seed from Bihar and the disinclination of the ryots to sell their surplus produce, a beginning has been made during the present year and the first parcel was sent to London in June last. In 1916, it is hoped to send larger quantities and to organize the work in such a manner that certain of the local wheat markets will in time be able to supply pure Pusa 12 to the shippers. The work in the Central Circle of the United Provinces in attempting to replace a country crop by a

new variety of better quality is an important undertaking which, if successful, will be a distinct step in advance. Up to the present, what has been done has been to produce improved wheats and to test them under cultivators' conditions. The next stage is to replace the country crop by the new kind and, while this is in progress, to convince the Home Millers that India can produce much more valuable wheats than those now exported. Once a large area is completely replaced, the wheat trade can supply itself and fraudulent admixture with local wheat will be rendered difficult.

Besides Pusa 12, two other new wheats, No. 4 and No. 6, are proving useful in certain parts of India. Where the supply of soil moisture is limited and where the general conditions require a rapidly maturing wheat, Pusa 4 is meeting a long-felt want. This variety possesses strong straw, good grain and is also practically immune to yellow rust. In Bundelkhand, it is being successfully distributed to the cultivators by Mr. Burt. As a cover crop for Java indigo in Bihar, this variety is also likely to be of use. The kind, however, which appears to suit Bihar best as a single crop is No. 6, which for the last few years has done exceedingly well on the Belsund estate. It is practically immune to both the common rusts in Bihar and seems to thrive even under adverse conditions. With the spread of drainage in Bihar, it will be possible to extend the cultivation of wheat and to make sure of a fair crop even in unfavourable seasons.

In addition to the results obtained in India, the new Pusa wheats have been tried with success in other countries. In the Argentine, where the ordinary crop is often damaged by hot winds before harvest, Pusa 12 and Pusa 4 have given good results and a stock of seed is being worked up for distribution on the Government farms. Equally favourable reports have been obtained from Australia and the Sudan. It seems probable that, in addition to India, Pusa will prove of use as a wheat-breeding station for the warmer wheat-growing areas of the world.

Wheat-breeding. Considerable progress has been made during the year in still further improving Indian wheats in the direction of increased rust-resistance, better standing power and higher yield. The past year has been perhaps the worst for wheat so far experienced at Pusa. The root development was poor, due to the warmth of the sub-soil, and, after the crop came into ear, the wet weather was followed by an epidemic of rust. Notwithstanding these adverse conditions, a good many of the cultures were not affected by either of the three rust fungi which attack wheat in Bihar. These new wheats are now in the fifth generation and are practically fixed.

Tobacco. The demand for seed of the cigarette tobacco, Type 28, continues to increase and a large quantity was distributed during the year. It will be necessary to raise still larger quantities of this seed in future years to meet the ever increasing demand. The seed was cleaned and separated into two grades before issue by a special machine on the principle of a corn dresser. All light and poorly matured seeds are removed and the resulting seedlings are stronger and more robust than those raised from ordinary untreated seed. The tobacco seed is so minute that only those individuals which are heavy and well filled contain sufficient reserve material for producing rapidly-growing seedlings.

During the year, the practical results obtained in the cultivation and curing of tobacco were published as a bulletin. These have been referred to in previous reports and it is unnecessary to repeat them here. The experiments connected with improved methods of raising tobacco seedlings and with green-manuring for this crop are being continued.

Progress has been made during the year in tobacco breeding and in the study of the inheritance of characters in both *N. tabacum* and *N. rustica.*

Indigo. A considerable amount of progress was made in the indigo investigations which enabled definite recom-

mendations to be placed before the planting community. A study of the so-called wilt disease, which has been responsible for the great diminution of area under Java indigo in Bihar in recent years, led to the realization of the important part played by the root nodules in the general economy of the plant and also in the production of indican. This in turn made it possible to perceive the factors on which the yield of indigo depends and to work out improved methods of production both of indigo and of indigo seed.

Indigo wilt was found to be the last phase in a starvation process which always takes place in this crop when the work of the root nodules is seriously interrupted. Wilt may be produced in two quite different ways. In the first place, when indigo has been subjected to long continued wet weather, resulting in a waterlogged condition of the ground and in an insufficient supply of air for the roots and nodules, the plants cease to thrive, growth slows down and the characteristic unhealthy foliage associated with wilt is produced. Such plants die slowly without setting seed and when the wilted condition has been reached are found to have lost most of their nodules and feeding roots. In the second place, wilt is produced in healthy plants growing in soil where there is plenty of air and moisture, when the nodules are suddenly deprived of their food supply. If rapidly growing Java indigo, sown in August for seed, is cut down to the ground in October, most of the plants die and only a few make fresh growth. In the majority of cases, this new growth is wilted and such plants maintain themselves during the cold weather with the greatest difficulty. Examination of the roots, soon after the cutting back, shows that the nodules are in a moribund condition. These results enabled improved methods of cultivation and of seed-growing to be devised, which were immediately tried and found successful on the indigo estates themselves.

The secret of success in the cultivation and management of both Java and Sumatrana indigo has been found

to be efficient surface cultivation in the hot weather combined with drainage in the monsoon. The hot weather cultivation, for which suitable implements have been introduced into Bihar, enables the crop to obtain an ample air supply and also leads to the destruction of weeds and to a great saving in the cost of production. Surface drainage on the Pusa system, by preventing the flow of surplus rain water over the indigo fields, assists in maintaining the essential air supply to the roots and nodules and so tends to increase the growth and to prevent wilt. The adoption of these methods on the Dholi estate for the 1914 crop led to a record yield both of finished indigo and of *seeth*.

The discovery of the nature of the wilt disease also led to a method of growing the seed of Java indigo which is rapidly being taken up all over Bihar. Formerly, the old indigo crop was kept over the cold weather and seed was collected from these plants. This placed the planters at the mercy of the season as, in many cases, the crop became so weak from wilt that it produced only a small quantity of poor seed. At the same time, very large areas had to be set aside for seed which became very foul with weeds. The new method makes the planter independent of the season and leads to the certain production of well-grown seed from a comparatively small area which can easily be kept in a clean condition. For seed, Java indigo must be sown in early August in high-lying, well-drained fields which are in good condition. The plants must be well-cultivated and properly spaced so that they grow rapidly and come into flower towards the end of October. At this period, the weather is warm and dry, bees are abundant and all the conditions for pollination are present. This method was adopted on the Dholi estate for the 1915 harvest when a very fine crop of seed of over eleven maunds to the acre was obtained. The land was afterwards kept through the hot weather and yielded crops of leaf in the ordinary way.

The provision of a better cover crop for Java indigo has enabled several estates in Bihar to reduce the cost of

cultivation. A new variety of wheat, Pusa 4, has been introduced which can be grown with indigo on high lands. This wheat is a rapid grower, does not tiller much, has a strong straw and is provided with few leaves. On this account, the young indigo plants get a full supply of light and air and the two crops do very well together. It is hoped later on, when this new wheat spreads, to establish a grade for the Calcutta market.

Among the items of investigation now in progress with regard to indigo may be mentioned the selection work on Java and Sumatrana and the experiments devised to increase the efficiency of *seeth* as a manure. New varieties of Sumatrana and Java indigo are being tried this year on an estate scale and the results will be dealt with later. Evidence has been obtained that a part of the value of *seeth* in tobacco growing is its power of aerating the soil and of providing the soil organisms and the roots of the tobacco with an adequate supply of air. If this is confirmed, *seeth* can probably be made to go further by adding the proper proportion of broken tiles (*thikara*) to the soil.

The progress that has already been made in the indigo investigations indicates that the prospects of resuscitating the industry are very favourable. The competition of the synthetic product has, for the time, been removed, a period of high prices has set in which will be the means of establishing confidence and of putting the estates which are growing indigo into order. The value of the industry to Bihar agriculture is considerable. *Seeth* is an excellent manure and the part played by the Java plant in the rotation in aerating the subsoil is much greater than is commonly realized. Apart from all the other aspects of indigo growing, the industry is well worth saving from the point of view of the welfare of the people and of the maintenance of the fertility of the soil.

Gram. For some years, a botanical study of the varieties of gram, cultivated in India, has been in progress at Pusa and a good deal of work has been done on the general requirements of this crop as regards soil and culti-

vation. A considerable volume of results has been obtained which has now been arranged for publication. As in Java indigo, the well-being of the crop depends to a very large extent on the physical condition of the soil and on a copious supply of air to the nodules and roots. The results obtained, on different classes of soil in the Botanical area, explain both the present geographical distribution of gram in India as well as the dependence of the yield of seed on the season. The two chief climatic conditions which limit the yield are heavy rains, which produce surface crusts and deprive the roots of air, and damp weather at flowering time which interferes with pollination. Self-pollination is the rule in gram at Pusa but instances of natural crossing occasionally occur. Twenty-five types, differing widely in habit and yielding-power, have been isolated which are now being tested for yield under varying conditions. One interesting fact has already come out of these variety trials, namely, the union of high yield and good quality in the same variety. Type 9, grown at Pusa for the last four years on a large scale, on widely varying soils and in very different seasons, has given an average yield of just over twenty maunds per acre. This is the second highest average outturn, the best being that of twenty maunds thirty-three seers yielded by Type 18. Taking both yield and quality into consideration, however, and on the basis of the valuation of Messrs. Ralli Brothers, Type 9 gave the best return, an average of Rs. 78-11-0 per acre while the average produce of Type 18, the highest yielder, was worth only Rs. 61-4-0 per acre. This result is another illustration of the value of selection methods in improving Indian crops in the present condition of agriculture in this country. Had an attempt been made by hybridization methods to achieve such a union of yielding power and grain quality, the work entailed would have been arduous and long continued.

Fibres. In 1910, a study of the varieties of *patwa* (*Hibiscus cannabinus*) was completed at Pusa when it was observed that one of the kinds, Type 3, appeared to be much more suitable for cultivation than any of the others. In

the account of this work published in 1911 (*Mem. Dept. of Agr. in India, Botanical Series*, Vol. IV, No. 2), mention was made of a possible method of keeping cultures of this type pure by removing heterozygotes in the seedling stage. If this could be done in practice, the difficulties with regard to vicinism in the case of a crop in which a good deal of natural crossing takes place, would be surmounted. Since that time, Type 3 has been grown from unprotected seed and every year the plot has been rogued in the seedling stage and again before flowering commenced. In this way, all heterozygotes have been removed and the kind has been kept pure, notwithstanding the many opportunities of crossing which occurred with the other types grown in the Botanical area. A pure seed supply having been obtained and the method of production having stood the test of time, steps were taken to work out the best way of retting and to obtain expert opinion on the produce as compared with the fibre produced locally. By cutting the plant at the proper time and retting it in clean river water, a very fine sample of fibre was produced which was submitted for opinion and valuation to Messrs. Wigglesworth & Co., 82, Fenchurch Street, London, E.C., who valued it at £18 per ton compared with £8 from the locally produced fibre. Messrs. Wigglesworth stated that the sample of Type 3 was "of excellent growth, being 10 to 12 feet long, exceptionally light-coloured, correctly retted and thoroughly cleaned. Judging by the individual stalks, I should conclude that the yield of fibre must have been of quite exceptional weight. The fibre is pure from end to end and is free from root. It is also of good tensile strength and I have no hesitation in pronouncing it the best specimen of fibre from the *Hibiscus cannabinus* plant which has ever been submitted to me. This class of fibre could be sold in almost unlimited quantities."

Great stress was laid by Messrs. Wigglesworth in their report on correct and thorough retting and on the importance of this in connection with manufacture. Their valuation will serve to draw attention once more to the

great increase in value of fibre, such as Deccan and *sann* hemp, which would immediately be obtained if more care were taken in retting and in placing the product on the market in the most suitable form. All this has been pointed out many times before but the fact that a carefully retted sample from India should have made such a favourable impression on the brokers proves how low is the present standard of preparing fibre in this country for the European manufacturers.

Seed of Type 3 can now be obtained at Pusa and trials of this fibre on some of the estates in Bihar are being arranged.

The work on the inheritance of characters in *Hibiscus Sabdariffa* and on *sanai* (*Crotalaria juncea*), referred to in the last report, was continued during the year and considerable progress was made.

Oilseeds. For some time, a botanical study of the oilseeds of India has been in progress at Pusa and the results obtained in the case of two of these crops—safflower (*Carthamus tinctorius, L.*) and *rai* (*Brassica juncea*, H. f. & T.), —have been prepared for publication. During the coming year, it is hoped to continue the study of Indian linseed.

Safflower. Both as a source of oil and to some extent of colour, safflower is widely distributed over many parts of India. The crop has been under investigation at Pusa for six years during which period a fairly detailed botanical study has been completed. Form separation has been undertaken, the heterozygotes have been removed and twenty-four different types, covering a considerable morphological range, have been studied in pure culture. The pollination mechanism of the flowers has been investigated as well as the influence of moisture on setting. Self-pollination is the rule in this crop but a fairly large proportion of crossing also takes place. In 1914, when the types were grown next to next in lines, this was proved to be about sixteen per cent.

The distribution of the red colouring matter (carthamin) to the flowers of safflower was found to be complex, indi-

cating the existence of a number of different colour factors. Carthamin is absent altogether in some of the types while in others it is but feebly developed. Dr. Marsden of Madras, who carried out some dyeing tests with the various types, found that the best colour bearing variety was eight times better than the worst. In the percentage of oil in the seeds, the range in values is nothing like so great as in the case of the carthamin content of the faded flowers. With one exception, the percentage of crushed seeds extracted by ether varied from 20·77 to 30·19. Nineteen of the twenty-four types contained over one quarter of their weight of oil. Oil and carthamin content were not found to be antagonistic and in several types high oil and high colour occurred together.

Indian mustard (*rai*). The most interesting feature of this crop, when studied in pure culture, was found to be the extraordinary range in form. One hundred and two pure types were isolated which varied from thirty inches to nearly ten feet in height. Almost every conceivable intermediate form between these extremes was represented and so close was the resemblance that in many cases the types would only be distinguished by the massed habit.

Self-pollination was found to be the rule in *rai* but crossing, to the extent of about fourteen per cent., occurred when the types were grown next to next in lines. The pollination details were found to agree in the main with those previously described in other species of *Brassica*. A certain amount of evidence was obtained on the inheritance of characters in this crop which indicated the existence of numerous factors. Time will not admit of this aspect of the work being continued.

Both in safflower and in *rai*, the results obtained in this study point to the overwhelming importance of selection in the improvement of crops like these in which some crossing takes place and where the range of form is so great. Form separation, if conducted on a broad basis, would almost certainly lead to the isolation of any desired type which could be multiplied at once and distributed to

cultivators. Hybridization work, on the other hand, begun without exhausting the possibilities in selection, might easily prove to be unnecessary even if, after many years of work, it proved successful.

Soil ventilation and drainage. For some time the existence of an important limiting factor in crop production has been suspected in India, namely, the want of sufficient air for the soil organisms and roots of plants. A large number of observations on plant growth have been made at Pusa, at Quetta and in other parts of India which can be most easily explained by a want of proper aeration of the soil. All the evidence obtained, as well as the results of a number of experiments, have been consistent with this view. During the year, a preliminary statement of the case was put forward in Bulletin 52 in which some of the work in progress was outlined. The volume of the gases in the soil is naturally bound up with the amount of water present and this in turn opens up many questions with regard to irrigation and to the saving of water in crop production. The practical applications of the views put forward are many and obvious. In some cases, they have already been translated into practice. The regulation of the air supply of the soil in the case of Java indigo has given important results which have been indicated above under that crop (p. 35). There seems little doubt that the future of the indigo industry in Bihar depends on the copious aeration of the soil in which this crop is grown. In the case of green-manuring in India, soil ventilation appears to be one of the chief factors on which success depends, while in tobacco cultivation in Bihar there is reason to believe that the cost of manuring can be materially reduced if means of permanently aerating the soil are adopted.

Perhaps the most important direction in which the air supply of the soil can be increased in Bihar is by means of surface drainage. A method has been worked out at Pusa and is now in successful operation on several of the estates in Bihar. This consists in dividing up the area

to be drained into areas, of from five to ten acres in extent, by means of a set of trenches, so devised that the surplus rain water is got rid of and, at the same time, soil erosion is prevented. On the Dholi estate, some remarkable results were obtained during the year. In one case, a large area, which previously gave little or no return on account of waterlogging, was so transformed in a single year by surface drainage that it was let out to ryots for chillies at a rent of ninety rupees a bigha, to the manifest advantage both of the cultivators and of the estate. In another case, a portion of the *zerat* which had previously been rendered very infertile by scour was let to tobacco growers, for the first time, at a rent of one hundred and forty rupees a bigha. Similar results have been obtained on other estates and there is little doubt that this improvement, the capital cost of which is not more than two rupees a bigha, will spread rapidly in Bihar. To obtain the best results, however, it will be necessary to study the rivers in North Bihar in detail and to draw up proper drainage maps and working plans. This aspect of the subject has been dealt with in Bulletin 53. The full development of drainage in Bihar is now beyond the means of the Botanical Section and can only be realized by the employment of engineers. Enough has been done, however, to show how much the production of Tirhoot can be improved by increasing the air supply in the soil by surface drainage. Bihar is now the waterlogged garden of India. Drainage would double its production.

III. The Development of the Agriculture of Baluchistan.

The preliminary work connected with the establishment of the fruit and agricultural Experiment Station at Quetta has been described in detail in previous reports. During the past year, the final details connected with the irrigation arrangements and storage of water were completed. In addition, a good many results of practical value were obtained.

Dry farming. The saving of irrigation water in wheat growing in India is one of the problems which is certain to receive, in the future, an increasing amount of attention on the part of the Agricultural Department. Any extension of the area irrigated by the water now available means increased revenue to Government and greater openings for the surplus agricultural population. At the same time, the less water applied per unit area, the smaller is the danger of waterlogging and of interference with the general healthiness of the locality. A study of the wheat crop under irrigation in many parts of India indicates that too much water is often given and that satisfactory crops can be grown with much less than is now applied. This is particularly the case in the Quetta valley, where good crops of wheat are only grown on heavily manured land which receives at least six and sometimes more waterings. These frequent waterings are considered essential, as the crop has to ripen under a rapidly increasing temperature and in a wind-swept area where the humidity is low. The circumstances at Quetta appeared to be exceedingly favourable for experiments in water saving. These have been completed during the year at the new Experiment Station and the results are of more than local interest. It has been found that very satisfactory crops of wheat can be grown on a single irrigation. This is applied to the land during September after which it is cultivated and sown in October. A good germination is obtained and there is ample moisture in the sub-soil for the development of a deep root system during the autumn and winter. After each fall of winter rain or snow, the soil moisture is conserved by harrowing with the Canadian lever harrow and, by the time the crop begins to shoot in March, there is a good deal of moisture left in the ground. There is also an ample supply of air for the roots and crops grown in this way ripen much earlier and better than the ordinary irrigated crop. The wheat thus escapes a good deal of the heat and dry winds of May and June. The yield obtained on an area of 2·85 acres of unmanured land at

Quetta on one irrigation was 47 maunds 24 seers or 16 maunds and 28 seers to the acre—an outturn which compares well with the average of 13½ maunds per acre grown on similar land with six or seven waterings.[1]

In the above experiment, the conditions were not very favourable. The rain which fell during the life of the crop was badly distributed. There was little rain in January and February while the late falls in April formed surface crusts which could not be broken up on account of the height of the crop. A yield of over 16½ maunds to the acre with one irrigation, compared with the average of 13½ maunds with at least six waterings, clearly proves that at the present time large quantities of valuable water are being wasted in growing wheat in the Quetta valley. There is little doubt that the same thing is taking place in the Punjab where the duty of irrigation water could be increased considerably.

Fodder crops. One of the great needs in Baluchistan agriculture at the present time is some crop by means of which the porosity and moisture holding capacity of the soil can be increased. Leguminous fodder crops, which can also be used as green manure, offer a possible solution of this problem and accordingly some attention has been paid to this matter.

Shaftal. The most promising fodder crop suitable for green-manuring purposes so far found at Quetta is Persian clover or *shaftal* (*Trifolium resupinatum*). When sown

[1] The results of numerous crop-cutting experiments in the District are summed up in the *Quetta Pishin Gazetteer* (p. 102) as follows :—

" In Quetta, 75 experiments were made in 1895-96 and the outturn of wheat per acre in irrigated land was found to be 15½ maunds, the highest being 17½ maunds in the Kasi Circle and the lowest 14 maunds in the Baleli and Durrani Circles. Mr. J. A. Crawford, in commenting on the items, remarked that the results of crop experiments were notoriously apt to be high. Further experiments, made in 1903-04, however, showed still higher returns, the average in irrigated and manured land being 24 maunds, 6 seers, and in irrigated land not manured 13½ maunds. In other parts, the average has been found to be as under :—

	Pishin Mds.	Shorarud Mds.	Chaman Mds.
Land irrigated and manured . .	25	15	15
Irrigated land not manured . .	16	12	10
Dry land	5	5	3

in August, under a thin cover crop of maize or *juar*, Persian clover, if properly managed, gives on good land three cuts of green fodder, weighing about 60,000lb. per acre, before the end of the following May. In addition, the last cut can either be ploughed in as a green manure or else kept for seed. The yield, however, is greatly reduced both by overwatering or by failure to cut the crop in time. The beneficial effects on the soil following *shaftal* are very great particularly on the tilth and general fertility. This is now being recognized and a considerable amount of seed was distributed in 1914.

Before *shaftal* can be taken up on the large scale by *zamindars*, some method of disposing of the crop to advantage must be found. The green crop is a safe fodder for horses and cattle and particularly for dairy cows, provided care is taken to mix it with sufficient *bhusa*. Lucerne, however, is undoubtedly a more popular green fodder and is now grown on a large scale round Quetta. Green forage, however, can only be produced in the summer and during the winter there is a large demand for dried fodder. This is at present met by lucerne, dried in the country fashion, without fermentation. The harsh and brittle nature of this food is obvious and it has the further disadvantage that it cannot be made into pressed bales. During 1914, experiments were made in the drying and baling of *shaftal*. By carefully adjusting the moisture it was found possible to make *shaftal* into good hay, to obtain the proper fermentation in the stack and to press it into bales. This can only be done in the exceedingly dry climate of Quetta by conducting the operation in all its stages in such a manner that the *shaftal* never becomes air dry. Once it is completely dried out, it is so brittle that it cannot be handled and baling is out of the question. The final product was indistinguishable from good English clover hay. Over a hundred bales were prepared in 1914 and tried as a fodder by one of the Heavy Batteries at Quetta during the winter. The Commandant reported that it was an excellent fodder, much superior to

dried lucerne. A much larger number of bales has been prepared during the present year which will be offered to various units of the Quetta Division for trial next winter. The military advantage of a pressed fodder, equal to English clover hay, is obvious in India while the extended cultivation of *shaftal* in the Quetta valley would be certain to increase production and thus augment the present supplies.

Lucerne. The methods of growing lucerne in Baluchistan are of some interest. The land is first of all manured before sowing and every year the crop is top dressed with more manure during the winter. There is no cultivation at any stage and water is applied by flooding the surface. The frequent manuring evidently promotes aeration of the surface soil and so removes some of the disadvantages attending the method of watering. Evidence has been obtained that surface cultivation of the lucerne after irrigation by means of the spring tine cultivator is likely to take the place of the manurial dressings. An experiment has been started to compare the yield of green crop under the two methods of treatment.

Some trials were made in 1914 to prepare and bale real lucerne hay in place of the dried unfermented local product. While it is possible to make good lucerne hay in the dry atmosphere at Quetta, the process is not easy on account of the fact that the moisture is so readily lost before fermentation takes place. *Shaftal* is much more easily made into hay at Quetta than lucerne.

Other fodder crops. Besides *shaftal*, several other new fodder crops have been tried. Ordinary English red clover grows at Quetta and withstands the hot weather of July but the rate of growth is not great and this fodder is not likely to compete with *shaftal* and lucerne. Italian rye grass behaves much like red clover but the difficulties connected with the germination of the seed under local conditions are likely to prevent this crop ever being taken up. A mixture of rye grass and *shaftal* was found to be unsuitable for hay as the rye grass dries much too quickly. Ber-

seem (*Trifolium alexandrinum*), which does so well in Sind, will grow at Quetta but the weight of crop is small and it is not likely to be of use in the valley. A Mediterranean fodder crop known as sulla (*Hedysarum coronarium*) was tried in 1914 at the suggestion of Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, but it proved a complete failure and was largely killed by the cold.

Fruit Investigations. *Improved fruit boxes.* The supply of improved fruit boxes for the use of dealers and the public was continued during the year. The demand is steadily increasing both on the part of the Indian dealers and also from the general public. About 2,500 boxes were sold during the year and as these are distributed all over India they ought in time to help to raise the present low standard of fruit packing in the country.

Some improvements have been made in the design of the packages for the five seer parcel rate. The use of chip compartments is being given up while the boxes are being made more thief-proof. In place of the separate chip compartments, a collapsible cardboard fitting has been used. This folds flat and is imported ready for use. Peach boxes entirely of cardboard were put on the market for the first time in 1914. The whole of the outside of the box consists of a single piece of cardboard and the boxes can be set up very rapidly. The separate compartments are of collapsible cardboard. With these boxes, thefts in transit are quite impossible. The supply was sold off at once and, judging by the demand, cardboard fruit boxes are likely to become exceedingly popular in India. They can be used several times over if necessary.

For consignments over five seers in weight, fruit packing cases must be made of wood and, to travel well for long distances under Indian conditions, it is essential that there should be a system of small units like the two pound punnets which are now being adopted at Quetta. There is one difficulty, however, which must be overcome, namely,

a reliable source of box boards at a reasonable price. Originally, these box boards were imported from Glasgow but the rise of wages and freights has increased the cost considerably. At the present time, the conditions of trade with Great Britain have still further increased prices. A large amount of time has been spent in trying to discover an indigenous source of suitable wood but without much success. India apparently has not yet reached the stage when cheap boxes are required in numbers. Most of the trade is still in the gunny bag and wicker basket stage. It is possible that after the war, the necessary boards for fruit packing boxes can be best obtained direct from Norway.

Supply of fruit trees. A beginning was made in 1913 in the supply of fruit trees to the public. Only good varieties which suit local conditions are propagated and care is taken to shape the trees in the nursery during the summer before they are distributed. The demand for this stock has rapidly increased and during the past year between four and five thousand trees were sold. No trees are given away and proper prices are charged. This tends to check waste and also ensures that most of the trees distributed are properly cared for afterwards.

Experience shows that the further development of fruit growing in Baluchistan is to a great extent a question of suitable varieties propagated on suitable stocks. A large collection of the best local and imported kinds is being made and added to every year. The experiments on the influence of the different stocks are already yielding most interesting results. The mahaleb, mariana, mirabolan and almond are likely to prove exceedingly useful as stocks in the Quetta valley. For the present, the first three have to be imported from France. With proper care, however, the percentage of deaths is very small and it might easily prove cheaper to import stocks in bulk than to raise a local supply. As the new varieties come into bearing and as the various experiments with stocks develop, it will be possible to improve the nursery work still further. Before the Experiment Station was started, no records of varieties had

been kept at Quetta so that all this work has had to be done over again from the very beginning.

IV. Programme and Publications.

Programme of work for 1915-16. *Plant breeding and plant improvement.* Work will be continued on the following crops, on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds and fruit.

Publications. Some progress was made during the last twelve months in the publication of results but the arrears have not yet been overtaken.

The following papers were published during the year :—

1. The influence of the environment on the milling and baking qualities of wheat in India. No. 3. The experiments of 1911-12 (with H. M. Leake). *Mem. Dept. of Agr. in India (Botanical Series)*, Vol. VI, No. 8, 1914.
2. Pusa 12. *Agr. Jour. of India*, Vol. X, Part 1, 1915.
3. The improvement of tobacco cultivation in Bihar. *Bulletin 50, Agricultural Research Institute, Pusa*, 1915.
4. First report on the improvement of indigo in Bihar. *Bulletin 51, Agricultural Research Institute, Pusa*, 1915.
5. Soil Ventilation. *Bulletin 52, Agricultural Research Institute, Pusa*, 1915.
6. Soil Erosion and surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa*, 1915.
7. Second report on the improvement of indigo in Bihar. *Agr. Jour. of India*, Vol. X, Part 2, 1915. Reprinted as *Bulletin 54, Agricultural Research Institute, Pusa*, 1915.
8. Report on Agricultural Botany for 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. Shaw, B.Sc.)

I. Charge and Establishment.

The Officiating Imperial Mycologist remained in charge of the section throughout the year. There were no changes in the establishment. The Officiating Imperial Mycologist was on tour for 77 days during the year and the First Assistant for 75 days; the "ufra" disease in Eastern Bengal, the wilt of chillies at Peshawar and the recent outbreak of "black thread" on rubber plantations in Burma absorbed most of this time. The number of mycological investigations in progress at some distance from Pusa, for Provincial Departments of Agriculture and Forest and Opium Departments, is increasing every year. All the staff have worked well.

II. Training.

Babu Jamini Bhusan Sinha, Fieldman in Mycology, Sabour, was under training from December 5th, 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona College, worked in the laboratory from 28th October to 5th November 1914. Mr. B. L. Gupta, B.Sc., of the Reid Christian College, Lucknow, completed a course in Mycology, which he commenced on 11th May 1914, and left Pusa on 8th July 1914.

III. Diseases of Plants.

The investigation of the diseases of crops, the collection and identification of Indian fungi and giving assistance to cultivators and officers of the Department formed the principal work of the section.

(1) **Paddy.** The work on "ufra," the nature of which was described in the last annual report, was continued and experiments were conducted at Comilla and at Pusa with a view to the discovery of some remedial measure. Owing to a deficiency of water in the experimental area at Comilla

this work did not give any conclusive results. The experiment is being repeated this year with additional precautions.

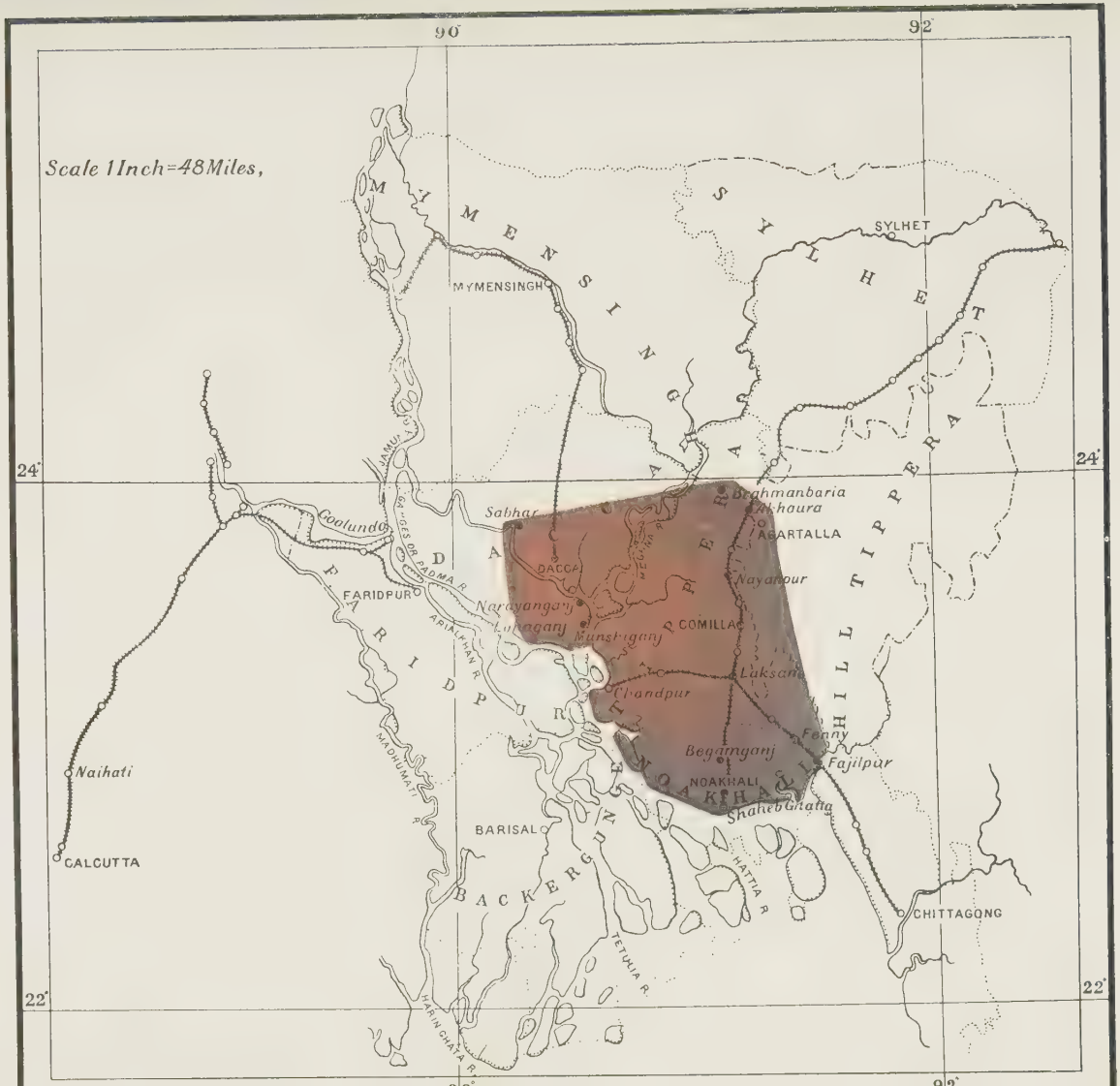
Working with small plots at Pusa it was found that the disease could lie dormant in the soil and infect a new crop. Cutting the diseased crop and burning it *in situ*, with a little kerosine, prevented the infection of a succeeding crop. It is unsafe, however, to generalise from a small experiment such as this, for it is possible to subject a small area to a much more thorough burning than would be practicable on a field scale.

The infected area in Eastern Bengal appears to be much the same as last year (see map) and the disease has been again reported in the vicinity of Ranchi, in Bihar and Orissa, where it is said to occur on transplanted paddy and not upon the early broadcast.

A diseased condition of the paddy crop in Balasore and on the Government Farm at Bankipore was investigated but "ufra" was not found; at Balasore drought appeared to be the cause of the trouble but at Bankipore the condition was said by local officers to be that known as "chatra," however, no trace of a parasite could be found.

The "gwa-bo" disease, which is the cause of extensive damage in Burma, was investigated without any very definite result. In some areas about 50 per cent. of the disease appears to be due to *Sclerotium Oryzæ* Catt. (vide *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. VI, No. 2, July, 1913) but it is almost certain that the diseased condition is the result of the combination of a number of adverse factors and is not due to the attack of any single parasite. In particular some insects appear to be responsible for a large amount of the disease.

(2) Tobacco. Field experiments with "tokra" of tobacco were commenced and yielded some results of scientific interest. *Orobanche cernua* Loefl. and *Orobanche indica* Buch. both occur on tobacco but *O. cernua* is much the more serious parasite of tobacco and solanaceous crops generally, while *O. indica* is a source of heavy damage to


90°
92°
Scale 1 Inch=48 Miles,
MYMENSINGH
SYLHET
24°
22°
Sabhar
Brahmanbaria
Akhaura
AGARTALLA
DACCA
Nayanpur
Coolundo
FARIDPUR
Narayanganj
Lohajanj
Munshiganj
COMILLA
Laksam
Chandpur
Fenny
Begamganj
Fajilpur
NOAKHALI
Shaheb Ghatta
Naihati
CALCUTTA
BARISAL
CHITTAGONG
HILL TIPPERA
BACKERGUNJ
MADHUMATI R.
ARIALKHAN R.
TETULIA R.
HATTIA R.
HARIN GHATA R.

Cruciferæ (*e.g.*, mustard, cabbage). A good crop of tobacco was raised on a field which had been under cabbages in the previous season and which was known to be infected with *O. indica*. Further experiments to test the effect of different chemical manures on the incidence of "tokra" are in progress.

(3) Rubber (Hevea). At the request of the Director of Agriculture, Burma, the section undertook the investigation of a disease of *Hevea* called "black thread" in Lower Burma. The disease is characterized by the appearance of longitudinal black lines in the naked tissue immediately above the tapping cut. These black lines mark areas of disintegration, stretching through the cambium into the wood, and as tapping proceeds they follow the fresh cut down the stem. The flow of latex becomes decreased, but, the most serious aspect of the disease is the failure of an infected tree to regenerate the bark over the tapped area.

Microscopic examination of the black cracks has, up to the present, failed to demonstrate the presence of any fungus parasite, but in the bark immediately adjoining the infected area hyphæ of a fungus often occurred. This fungus was identified as *Phytophthora* the cause of the "canker" of Hevea. At the moment of writing the investigation has not been carried further but experiments are in progress.[1]

(4) Sal tree (Shorea robusta). At the request of the Bengal Forest Department the section undertook the investigation of a disease in the sál forests of the Duars, said to be due to a fungus parasite. In the Buxa Division a considerable number of sál trees can be seen in a dead and dying condition. When dead the trees are left standing bare and leafless and in dying trees the foliage is scanty and there are obvious indications of a decrease in vigour of growth. In all the dead and dying trees which were examined there were indications of a fungus attack in the roots. If the main root of an unhealthy tree is laid bare

[1] Infections with pure cultures of this *Phytophthora* have since been successful in producing this disease on healthy trees.

to a depth of about 3 feet and the outer corky tissues are cut away with a knife it is found that the phloem has been destroyed leaving nothing but the bast fibres; in the disintegrated tissue between the strands of fibres white rhizomorphs occur and a fungus mycelium is everywhere common. In dead and badly affected trees this condition is found to extend up the trunk sometimes as much as 2 feet above the soil. In such cases a fructification of a bracket fungus (probably *Fomes*) is often found on the stem. In every case examined in which this fructification was present the phloem showed the diseased condition described above. Thus while all unhealthy trees show a diseased condition of the phloem, with the presence of a mycelium with rhizomorphs, the most advanced cases of disease also bear a sporophore. From field observations therefore there is a strong presumption that the disease is due to the attack of a basidiomycete of the genus *Fomes;* the fact that this fungus is one of a group which is responsible for most diseases of timber strengthens the evidence and moreover the presence of rhizomorphs in the diseased phloem is what would be expected in association with a *Fomes* fructification on the exterior of the trunk.

The fungus has been obtained in pure culture and will be tested by inoculations. While it is not unlikely that the fungus is the direct source of damage it will probably be found that the conditions under which the sál trees are living are such as favour the presence of a fungal parasite and decrease the vitality of the sál tree. When the factors which are necessary for the fungus to gain entrance into a healthy sál tree are known it may be possible to control the disease by altering the hygienic conditions under which the trees live and thus lessening the chances of a successful infection. It is improbable that it will be possible to apply any remedial measures in dense jungle such as occurs in Buxa; treatment might, however, be possible in the case of plantations.

(5) Rhizoctonia. Work on this fungus was continued and the results are published as a memoir of the Depart-

ment. The species *R. Napi* West. was found to be a dangerous parasite of mustard and gram. This fungus is incapable of active growth at temperatures above 29°C.—a circumstance which limits its depredations in India. A fertile stage was discovered and found to be identical with the well known *Botrytis cinerea* Pers., which was described as a disease of mustard by Frank some forty years ago. As a result of this it is considered that *R. Napi* is not a true member of the genus *Rhizoctonia*, which should be restricted to those species with a fertile stage in the genera *Corticium or Hypochnus*. The species *R. destruens* Tass. was found to be the cause of serious disease of betel vine and potato in Lower Bengal, Bihar and parts of Bombay. In the latter province it also occurred on suran, lucerne and groundnut. There were some indications that the fungus had a perfect stage in the genera *Corticium* or *Hypochnus* but no satisfactory proof could be obtained. Experiments suggested that corrosive sublimate was a more reliable fungicide against *Rhizoctonia* than formalin or copper sulphate.

In continuation of the research into the blight of opium poppy experiments were conducted with a view to discovering whether *Rhizoctonia* or *Peronospora* was the chief cause of this disease. Poppy was grown at Pusa from seed supplied by the Opium Department and the resulting crop became infected with *P. arborescens*. This fungus was also very plentiful on poppy in the vicinity of Ghazipur, but at Patiali *Rhizoctonia*, and not *Peronospora*, was found. The matter cannot be regarded as definitely settled but it is probable that *Rhizoctonia* is only a serious parasite of poppy when conditions such as poor soil or defective drainage are inimical to the growth of the crop.

(6) Anthracnose. The investigation into anthracnose of betel vine did not yield any results of practical importance. There is no doubt, however, that the perfect stage of this *Colletotrichum* is an ascomycete belonging to the genus *Glomerella*. Attempts to secure successful inoculations failed and our knowledge of this disease is therefore not

in so good a position as it appeared to be last year. The well known anthracnose of chillies appears to be the cause of a good deal of trouble in the chilli growing districts of Burma and some form of treatment may be necessary.

IV. Miscellaneous.

A certain amount of work was done on the fungi of Pusa soil. The chief interest of this preliminary investigation was the striking similarity between the fungus flora of an Indian soil and that which occurs in Europe. The species isolated in Pusa were—

Cunninghamella elegans Lendn.
Aspergillus fumigatus Fres.
Aspergillus niger v. Tiegh. *Sterigmatocystis nigra* v. Tiegh.
Rhizoctonia Napi West.

of which the first three are all known in the soil in Europe.

The fungus which causes " red rot " of sugarcane was found to be parasitic upon juar under laboratory conditions but so far is not known to cause serious damage to this crop in the field. A rot of bananas was examined by the First Assistant and found to be due to a parasitic *Fusarium*. A preliminary account has been published in the *Agricultural Journal of India*, it appears that the disease is distinct from the well known Panama disease of bananas. The results of some observations on potato blight in India have been published as a memoir of the Department, the chief point of practical importance is the fact that the fungus cannot survive in the heat of the plains. Mr. Dastur has continued his work on *Phytophthora* with the study of some forms parasitic on *Vinca*, it is hoped to publish results shortly.

Some preliminary work on the disease of chillies at Peshawar indicated that the disease was of the type known as " wilt." Inoculations with a fungus isolated from diseased plants were not successful and this year the incidence of the disease is much less. Treatment of oat smut

with formalin on certain estates in Bihar was, as usual, completely successful.

V. Systematic Work.

The additions to the herbarium amounted to 155 specimens during the year. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments. The publication of systematic mycology by the Imperial Mycologist has been largely done in collaboration with Herrn H. and P. Sydow of Berlin; the outbreak of war with Germany has of course prevented this collaboration being continued and will hinder the publication of the series "Fungi Indiae Orientalis."

VI. Programme of work for 1915-16.

(1) *Research work.* All new fungus diseases of crops will be the subject of investigation as they come to the notice of the section but the following diseases will receive special attention and will constitute main lines of investigation :—

(1) Ufra of paddy.
(2) Smut of sugarcane.
(3) Wilt of cotton, sesamum, gram and chilli.
(4) Black thread disease of rubber.
(5) Blight of opium poppy.
(6) Root rot of sál tree.

Research work will also be continued upon phanerogamic parasites and fungi of the soil.

(2) *Systematic work.* The care of the herbarium will continue to form an important part of the work. Minor papers on systematic mycology will probably be published.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may be given as necessary.

(4) Routine work of advising on plant diseases will be continued and assistance will be given as usual to Provin-

cial Departments of Agriculture, the Forest Department, Planters' Association and general public.

VII. Publications.

(1) Butler, E. J. . The cultivation of Rice in Spain and the Recent International Rice Congress at Valencia. *Agri., Jour., India, IX, Pt.* 4, Oct. 1914.

(2) Dastur, J. F. . The Potato Blight in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 3, April, 1915.

(3) Shaw, F. J. F. . Report on Mycology, 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(T. Bainbrigge Fletcher, F.E.S., F.Z.S.)

I. Charge and Establishment.

The Imperial Entomologist held charge of the section throughout the year. Mr. A. J. Grove, Supernumerary Entomologist, whose services had been lent to the Punjab Department of Agriculture since 27th January 1914 for the investigation of insect damage to stored wheat, left the Department on 27th April 1915 on termination of a six months' extension of his probationary period. Mr. G. R. Dutt was on privilege leave from 5th October to 4th November 1914 and Mr. D. Nowroji from 5th to 31st October 1914. The services of G. D. Ojha, Fieldman, were lent to the Department of Agriculture, Central Provinces, for six months from 5th April 1915 in connection with work on *Nephotettix*.

II. Tours.

The Imperial Entomologist was on tour in Burma from 26th July to 6th October, in the Punjab and North-West Frontier Province from 9th to 25th October, in the Central Provinces from 9th to 18th April, in the North-West Frontier Province from 13th May to 1st June and also visited Calcutta to work at the Indian Museum from 14th to 23rd June, a total absence from headquarters of 130 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces in July 1914 to investigate cane-borers and again in February 1915 to inquire into an outbreak of *Nephotettix* in rice areas for which purpose he also toured in the Central Provinces and Orissa from 5th to 21st June 1915. He also visited the Karauli and Benares States in February and May respectively to advise regarding development of the lac industry.

Mr. C. C. Ghosh visited the Sepaya Farm in September 1914 to examine the indigo planted in connection with *Psylla* experiments.

Mr. G. R. Dutt toured in Southern India from 29th March to 17th May 1915 to collect information and specimens of insects, especially Hymenoptera.

Mr. M. N. De, Sericultural Assistant, visited Muktesar in October 1914 to distribute directly from there the univoltine mulberry silkworm eggs which had been placed in cold storage during the hot weather. He also went to Calcutta in November 1914 to assist in displaying the silk exhibits sent from Pusa for the Exhibition of Indigenous Products as compared with Enemy Goods.

The Fieldmen were sent on tour as occasion required throughout the year in connection with outbreaks of pests.

III. Training.

No students completed the course in Entomology during the year but two were received from the Punjab in June 1915. G. D. Ojha and Harihar Prasad, Entomological Fieldmen at Pusa, were also given some special training. The short courses in Lac and Sericulture only attracted four students, a number much below the average; the Banswara State, Central India, sent one man for the Lac course in June 1915, one student completed a course in Eri and Mulberry Silk and two Sericultural students remained under training at the close of the year. The reduction in numbers of the short-course students seems to be directly due to the publication of popular Bulletins on the culture of lac and silk, although it may be noted that mere book-instruction cannot take the place of practical work.

IV. Crop Pest and other investigations.

1. Cotton Pests. Experiments, which are still in progress, were made to test the relative immunity of different varieties of cotton to attacks of bollworm (*Earias*). A large number of sowings were made of numerous cottons from the United Provinces, the Punjab, the Central Provinces and

Bombay in combination with other malvaceous plants, and weekly counts made of the bollworm infestation. The bollworms found were also examined for the presence of parasites, which were recorded, bred out and liberated in the experimental area. So far as noted hitherto the infestation of *Earias* by *Rhogas* is remarkably small (less than 5 per cent.) even under the most favourable conditions, and it would appear that the influence of *Rhogas* has been greatly exaggerated. In May and June 1915, in compliance with a request from the Director of Agriculture, all the *Rhogas* pupæ obtained were sent to the Punjab to assist in establishing the parasite there.

Some work has also been done on the life-history of *Machærota planitiæ*, whose nymph lives in a curious calcareous tube on stems of cotton. The presence of this insect frequently stunts the growth of the young shoots and it may occur in sufficient numbers to do considerable damage.

2. Sugarcane Borers. Borers in sugarcane (both new sowings and ratoon canes), maize, *juar*, and rice stems and stubble have been collected and the insects bred out for further study and comparison. Affected canes were also received from the North-West Frontier Province and the insects reared. In March 1915 fresh sowings of cane were made with maize as a trap-crop and, as soon as the presence of borers became apparent, these were collected, counted and reared for further study to ascertain whether the borers in cane and maize are really distinct; this experiment was not concluded at the end of the year.

3. Garden Pests. The study of pests of fruit-trees, flowers and vegetables was continued and illustrations made for a Bulletin on Fruit-pests.

4. Parasites of Scale-insects. With a view to sending parasites of *Aspidiotus aurantii* to Italy, a study was begun of the parasites of this scale-insect which occurs commonly at Pusa on *Citrus* spp. and roses, but very few parasites could be obtained.

A large amount of Lecaniinæ material was collected with a view to finding any parasites which might be of use in the control of *Coccus viridis* (*Lecanium viride*) in the coffee districts of Southern India, but it was found that the majority of the local *Lecaniinæ* were free from Chalcid parasites; only those scales found on *Ficus religiosa* and *Ricinus communis* were parasitized to any extent.

5. Parasites of Aleurodids. As noted in last year's report, attempts have been made to procure a parasitized colony of *Aleurodes citri* for export to Florida. The parasite which attacks *A. citri* on *Jasminum* is the same as the one which attacks *A. ricini* on castor, and castor plants were therefore grown and infected but unfortunately became heavily infested with *Tetranychus bimaculatus* and later on by a leaf-fungus and the plants therefore had to be rejected. A very similar parasite attacks another *Aleurodes* on *Ficus* and trials with this are also being made.

6. Economic Aleurodidæ. Life-histories of *Aleurodes citri*, *A. bergi*, and *A. ricini* were completed.

7. Pyrilla aberrans. The complete life-history of *Pyrilla aberrans* was worked out during the year and repeated thrice to check the period of a life-cycle. Chalcid, Dryinid and Stylopid parasites were also reared, some of these being new. It may be noted that three species of *Pyrilla* (*P. aberrans*, *P. perpusilla* and *P. pusana*) are found on sugarcane at Pusa, all formerly confused under the first name.

8. Nephotettix bipunctatus. Much time was given to the outbreak of *Nephotettix bipunctatus*, the rice leaf-hopper (locally called "Maho") in the Central Provinces. This insect was first reported as a pest from the Sakti State in the Bilaspur District of the Central Provinces. A Fieldman was sent to make investigations on the pest and to try measures suggested from Pusa. These measures consisted of (1) bagging with large field bag-nets, (2) bagging with hand-nets, (3) brushing over the infested fields with a rope dragged over the plants, (4) oiling the infested fields with kerosine and then dragging a rope across so as to

submerge the plants temporarily, (5) spraying with contact insecticides, and (6) putting up lantern traps in the affected fields. Of these, it was found that the last was the most efficacious and that most readily adopted by the cultivators.

A leaflet on this pest in English and Hindi was written and issued by the Department of Agriculture, Central Provinces, and widely circulated amongst the cultivators of the affected districts. It has also been translated into Uriya and issued by the District Board in Balasore, where an outbreak of *Nephotettix* also occurred. A trained Fieldman was lent to the Central Provinces to carry on continuous observations of the pest and to advise adoption of remedial measures in the Raipur and Bilaspur districts which were severely infested last year.

9. Life-histories. In the insectary were reared some two hundred insects which had not been reared previously. Considerable attention has been paid to various insects (mostly Coleoptera) found at and just below soil-level and about sixty different beetles have been reared and their breeding-places, earlier stages, food and habits noted. Many of these beetles are predaceous and are therefore beneficial by destroying plant-feeding crop-pests; amongst such may be noted an unidentified Carabid predaceous on a Cydnid bug, a species of *Chlænius* predaceous both in the larval and adult stage on caterpillars of *Utetheisa pulchella*, and several Elaterid beetles. Of these last a single grub of *Agrypnus* sp. ate more than 200 Scarabœid grubs in the course of about three months, and another Elaterid larva was found to exercise a considerable check on Tenebrionid grubs feeding at the roots of gram and other crops.

A point, which has been observed with regard to some common insects (*Laspeyresia*, *Chilo*, *Chloridea*) reared for observation of exact cycles of their life-history, is that out of the same batch of larvæ, feeding and commencing to hibernate at the same time, some hibernate and emerge as adults whilst others hibernate during the cold weather,

then æstivate during the hot, dry season and emerge at irregular intervals thereafter as late as July or August. From the practical point of view of control this is of some importance, as measures taken on the first appearance of the insects after hibernation may be rendered abortive, or will at least require to be supplemented, in view of these later emergences. An observation of this kind, apparently trivial in itself, emphasizes the fact that an intimate knowledge of the habits of the insects concerned must be the first step towards their control.

Crocidolomia binotalis is a cold weather pest of Cruciferæ. Unsuccessful attempts were made to find out how it passes through the rest of the year.

Zonabris pustulata is an extremely common black and red Blister beetle whose life-history is yet unknown. Eggs were obtained in November 1914 and hibernated in the soil, hatching at the end of the cold weather, but all attempts to get the young larvæ to feed on eggmasses of various grasshoppers proved unsuccessful, and the grubs could not be reared. Dr. Roepke, of the Experimental Station at Salatiga in Java, has recently informed me that he found larvæ of this species feeding on eggmasses of *Cyrtacanthacris;* it is probable that this beetle has a similar habit in India.

Another failure was encountered in further attempts to obtain the life-history of *Anthia sexguttata*, a giant Carabid which feeds in the adult state on practically any insects it is able to catch.

A Bruchid beetle (*Bruchus affinis*) was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. These seeds have been treated and stored in various ways to ascertain the extent of damage and how it can best be checked.

An unidentified Dermestid beetle in stored wheat has been found to complete its transformation in from one to two years.

Further observations have been made on the life-history of *Odoiporus longicollis*, a weevil which bores in plantain stems, and the life of the adult beetles has been found to extend to a period of up to two years.

With reference to the campaign against *Agrotis ypsilon* at Mokameh it was not known how this insect passes through the hot weather and rainy season in the plains of India. Large numbers were therefore obtained in March and it has been found that, under conditions in the Insectary, continuous broods have been obtained, which suggests that it may breed somewhere in the vicinity of the areas attacked in September-December.

The status of *Tenebroides mauritanicus* as a grain-pest having been doubtful, this was ascertained by experiments, by which it was found that this beetle and its larvæ certainly can and do eat wheat and rice grains, preferring wheat to rice. The adult beetle preys upon the adult rice weevil, *Calandra oryzæ*, so that in grain affected by *C. oryzæ* the presence of these beetles is beneficial as, when present in sufficiently large numbers they will ultimately rid the grain of the weevils although they themselves will eat a small proportion of the grains; but the resultant loss will be less than if the weevils bred unchecked. Further experiments will be undertaken with this insect.

Batocera rubus, a longicorn beetle commonly boring in Fig, Mango, etc., has been reared from the egg and the complete life-cycle observed to occupy a year.

Balaninus c-album has been traced throughout the year, though not reared from eggs. The life-cycle occupies a year.

Complete life-cycles have been observed of *Plotheia celtis*, *Porthesia xanthorrhœa*, *Perigea capensis*, *Spodoptera mauritia*, *Liogryllus bimaculatus*, *Terias hecabe*, *Hypolimnas bolina*, *Euplœa core*, *Junonia orithiya*, *Huphina nerissa*, *Papilio polytes* and *Deilephila nerii* and further observations have been made on numerous other insects.

Fruit-flies have been reared in large numbers—in thousands in some cases—from various fruits in order to procure parasites and to ascertain the proportion parasitized. In the case of *Bactrocera cucurbitæ* the results have been disappointing as parasites were very few and it is perhaps owing to this fact that this fruit-fly does so much damage to cucurbitaceous vegetables. Only in one lot of fruits of *Momordica charantia* were the maggots found to be attacked by a Braconid parasite to the extent of about 16 per cent., and even this parasite was not found to be present throughout the year. The peach-flies (*Bactrocera zonata*) showed an insignificant percentage of parasitism and the parasitic grubs were observed to remain in a resting condition throughout the remainder of the year.

Carpomyia vesuviana was reared from fruits of Ber (*Zizyphus jujuba*) and was found to be extensively parasitized. Attempts will be made, at the request of the Royal School of Agriculture at Portici, to introduce this parasite into Italy, whence this fruit-fly was originally described its specific name being derived from the fact that the original specimens were taken on the slopes of Mount Vesuvius. The flies remain in the pupal state for some time, from about February to June or later, but the parasites emerge about March and probably have an alternative host.

In order to test the effect of poisoned sprays on fruit-flies long series of flies reared in the insectary were fed with a solution composed of Lead Arsenate $2\frac{1}{2}$ to 5 oz., *gur* $2\frac{1}{2}$ lb. and water 4 gallons, and it was found that a strength of 3 to 5 oz. of Lead Arsenate kills the flies in about 36 hours.

A Braconid parasite of *Diacrisia obliqua* was bred for a generation to note its life-cycle and rate of increase and some work was also done on an Ichneumonid parasite of *Spodoptera mauritia*.

Odontotermes assmuthi, the largest of the five Termites known to occur at Pusa, has been under observation for the last four years. From the emergence of adults which

took place in July 1914 several observation nests were established in the Insectary and new colonies were successfully started and soldiers and workers reared. This is the first time, so far as I am aware, that any species of the true earth-dwelling *Termitidæ* has been reared from the egg to any adult stage under observation, although some of the woodliving *Protermitidæ* and *Mesotermitidæ* have been reared in Europe. Further colonies are now being reared.

10. Insecticides. Experiments in the preservation of wood against attacks of Termites (White Ants, so called) were continued, the species of Termite experimented with being *Microtermes obesi* (*anandi*), which is apparently a common species throughout the plains of India. "Powellized" wood, supplied by the agents for testing, has failed almost wholly within four years. "Sideroleum," tested as a preservative of wood against Termites, has also failed; further tests will be made of it. Testing of "Microlineum" as a preservative has been started.

Creosote was tried to make sugarcane setts immune to Termites without interfering with germination, but these experiments failed.

11. Stored grain pests. A series experiments on the preservation of rice, wheat and pulses against insects under stored conditions has been commenced on a small scale. The methods found most effective will be tested on a larger scale.

12. Silk. One student completed a short course in Eri and Mulberry and two were undergoing training at the close of the year. The univoltine mulberry silkworm eggs, which were sent to Shillong and Muktesar for rearing in March, gave satisfactory results but those sent to Muktesar for rearing in October did not hatch properly as the natural temperature of the place from July to October was not sufficiently low. Our attempts to establish a superior stable multivoltine hybrid race, which would not degenerate, were continued. Mulberry silkworm eggs were supplied to 171 rearers and eri eggs to 144 applicants and

mulberry and castor seeds to 20 applicants. One Fieldman and a rearer were sent to Jeolikote, Kumaon, for rearing eri worms in April and May as it is difficult to procure a fresh stock of eggs for distribution in June and July. Thirty-one pounds of eri cocoons were supplied to Messrs. Inagaki & Co. of Kyoto for testing in the mills of Japan. Difficulty was experienced by the rearers in disposing of eri cocoons in small lots. Silk exhibits were sent to Exhibitions held at Muzaffierpur, Monghyr, Pudukottai, Mysore and to Calcutta, Madras and Cawnpur in connection with the Exhibition of Indian as contrasted with German and Austrian goods. The Secretary of the Mysore Dasara Exhibition awarded a silver medal for the exhibits. Eighteen silk pieces were loaned to the Director General of Commercial Intelligence, Calcutta, for the Exhibition of Indian as contrasted with Enemy Goods. Eight sets of silk exhibits were sent to the Superintendent, Central Seedstore, Bengal, Sibpur. His Highness the Maharaja of Darbhanga took a keen interest in all the operations of the industry during His Highness' visit to the Institute. Instruction was given by correspondence in silk-dyeing, bleaching, silkworm rearing, reeling and spinning. Rupees 937 worth of silk, manufactured at Pusa, was sold.

13. Lac. During the past year emergences of larvæ took place on the 28th September 1914 and 10th June 1915 and in the two seasons 120 Ber trees were inoculated. Broodlac was supplied to 7 persons. Specimens of lac from two new food-plants, which were not hitherto recorded, were received from the Honorary Secretary, Agri-Horticultural Society of India, Calcutta, and the Economic Botanist, Lal Bagh, Bangalore. Parcels for sending in lac specimens were sent only to such Forest Officers from whose Division or Range the series of specimens was not complete. Unfortunately serious gaps occurred in the past and these have not been filled up as yet.

Five tubs containing Kusumb (*Schleichera trijuga*) plants were inoculated and despatched to Mr. N. Fujii,

Hozan, Formosa, through the Consul-General for Japan Calcutta.

During the year the services of Mr. C. S. Misra, First Assistant, were requisitioned by the Karauli Durbar to report on the progress of lac cultivation started by the Forest Officer of the Durbar who was trained in Lac work at Pusa. A separate report embodying his suggestions was submitted to the Durbar through the Political Agent Bharatpore.

In May 1915 Mr. Mistra's services were requisitioned by the Benares State to advise on the possibility of extension of Lac cultivation in the Chakia district of the State. A separate report on this embodying his suggestions has been sent to His Highness the Maharajah of Benares through the Political Agent to His Honour the Lieutenant-Governor of the United Provinces, Benares.

A student was deputed by the Banswara State in Central India to undergo a month's training in Lac culture. The student joined the course on 7th June 1915 and went back to the State on the 3rd July 1915.

Copies of the Lac Bulletin in English and Hindi were sent or sold to numerous inquirers.

14. Bees. During the year experiments with the Indian Bee (*Apis indica*) were continued, special attention being paid to the three principal defects of this bee in the plains, *viz.*, (1) deserting the hive in autumn, (2) inability to defend the hive against Wax Moth, this being one of the causes which lead to desertion, and (3) frequent swarming.

The results obtained this year go to show that the bees can be prevented from deserting the hive and a little care prevents the Wax Moth, a well-made hive being of great help in this direction. A little care bestowed on these bees leads to an increase of the population in the colony but stimulates swarming. Efforts made at checking swarming were not successful. It appears that the old principle of inducing swarming early in the season so as to have a number of colonies from which to take surplus honey in the honey season, will be more suitable to these bees than the

new principle of checking swarming and having larger surpluses from strong and populous colonies. The work will be continued. A Bulletin on Bee-keeping was issued at the close of the year.

V. Illustrations.

Illustrations were prepared, to the extent of artistic assistance available, of the insects studied during the year. Coloured plates, showing the complete life-history, were prepared during the year of the following insects :— *Utetheisa pulchella*,* *Odoiporus longicollis*,* *Atractomorpha crenulata*, *Oxycarenus lætus*, *Plusia orichalcea*. *Perigea capensis*, *Etiella zinckenecllu*, *Glyphodes indica* and *Chilo simplex*,* of which those marked * are printed and available. Numerous line drawings have also been made and will be utilized as occasion arises. The issue of coloured plates and lantern slides has been continued.

VI. Miscellaneous.

Correspondence. A total of 103 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,119 letters were received and 1,374 issued, but these numbers are exclusive of a large amount of routine correspondence.

VII. Insect Survey.

Steady progress has been made in additions to and arrangement of the collection. The whole of the collection of *Hymenoptera* has been rearranged in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, and other groups will be taken up as time and staff permit. The following collections were sent to specialists in the groups named and our thanks are due to them for the help afforded :—Chalcididæ to Dr. L. O. Howard, Formicidæ to Mr. W. M. Wheeler, Stylopidæ to Mr. Dwight Pierce, Dryinidæ to Mr. J. C. Crawford, Rhynchota to Mr. W. L. Distant, Coccidæ to Mr. E. Ernest Green, Noctuidæ and

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Pyralidæ to Sir George Hampson, Rutelidæ, Cetoniadæ and Dynastidæ to Mr. G. J. Arrow, Carabidæ to Mr. Andrewes, Histeridæ to Mr. George Lewis, Curculionidæ (part) to Mr. G. A. K. Marshall, Lucanidæ to Mr. F. H. Gravely, Microlepidoptera to Mr. E. Meyrick, Trypaneidæ to Professor M. Bezzi and their parasites to Professor Silvestri, and various Diptera to Mr. E. Brunetti.

Our thanks are due to His Excellency Lord Carmichael for a small named collection of moths from Darjiling.

Numerous sendings of specimens of insects have been identified for correspondents as far as possible.

Collections of flies, bugs, lice, ticks and other animals of interest as disease-carriers, made during the year at Pusa and whilst on tour, were transferred to the Imperial Pathological Entomologist.

VIII. Entomological Conference.

A meeting of the Entomological staff both of Pusa and the Provinces, was held at Pusa from 2nd to 8th February 1915. Similar meetings have been held previously, but not since 1909, and have hitherto been confined purely to the Agricultural Department. Opportunity was taken of the present occasion to extend the scope of the meeting to include others engaged in similar entomological work, and the Forest Zoologist, the Entomologist in the Indian Museum, and the Entomologist to the Indian Tea Association were also invited and attended and gave us the benefit of their experiences with various insects, which were of mutual interest. Besides these, Mr. E. Ballard, Government Entomologist in Madras, came from Coimbatore and Mr. E. J. Woodhouse, Economic Botanist, Bihar and Orissa, attended part of the meeting, whilst the Central Provinces and Bihar and Orissa each sent both their Entomological Assistants, and one came also from each of the following Provinces and States, *viz.*, Madras, Bombay, United Provinces, Assam, Baroda and Travancore.

An abstract of crop-pests had been prepared beforehand and specimens of each got out in show-cases in order that

there might be no doubt regarding the identity of any species under discussion. The list was worked through systematically and each insect discussed as regards its distribution, crops attacked, damage done, control, etc. The gaps in our knowledge respecting distribution especially, which revealed themselves during the meeting, were emphasized by the absence of the Entomological Assistants from Burma, Bengal, the Punjab and North-West Frontier Province, but in spite of this the meeting proved most valuable, especially to the Provincial Staffs, who are thereby helped to keep in touch with our work done at Pusa and that done in Provinces other than their own. It is hoped that similar meetings may be held regularly in the future.

IX. Programme of work for 1915-16.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in Silk, Lac and Bee-keeping will be continued, and new Insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually published during the year under review :—

Books.

Some South Indian Insects, by T. Bainbrigge Fletcher. (Madras Government Press, Imperial 8vo., pages xxii + 565, 50 Plates and 440 text-figures.)

Bulletins.

No. 28. The Cultivation of Lac (Hindi edition), by C. S. Misra.

No. 39. Instructions for rearing Mulberry Silkworms (Bengali edition), by M. N. De.

No. 44. How to Improve Silk Reeling in Bengal, by M. N. De.

No. 46. Bee-keeping, by C. C. Ghosh.

No. 48. First Report on the experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled by M. N. De.

Leaflets.

Maho (*Nephotettix bipunctatus*), by C. S. Misra (published by the Agricultural Department of the Central Provinces in English and Hindi and by the Balasore District Board in Uriya).

Practical Instructions for the Kollegal Mulberry Silkworm Rearers, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflet* No. I of 1914.)

Some General Methods of Controlling attacks by Insect Pests; Agricultural Methods; Mechanical Methods, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflets* III and IV of 1914.)

Miscellaneous.

Note on Tiger-Beetles from Coorg, by T. Bainbrigge Fletcher. (*Journal of the Bombay Nat. Hist. Soc.*, XXIII, 379.)

Report on Agricultural Entomology for 1913-14 for the Board of Scientific Advice for India, by T. Bainbrigge Fletcher.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett, B.A., F.E.S.)

I. Administration.

I was in charge of the section for the year, save for the period July, August, and September 1914, when I was absent on privilege leave and Hill recess. Mr. P. G. Patel was absent on privilege leave for 29 days and Mr. H. N. Sharma for one month and 20 days.

II. Educational.

No educational work was done. Mrs. Kilby and Mr. Awati worked in the laboratory for some time, the former at the reflexes of *Cimex* (*Clinocoris*), and the latter at the taxonomics of *Muscidae*.

III. Research.

There have been three main lines of enquiry :—

(1) A thorough investigation of the flies and other insects which breed in decaying or septic animal matter, including those that infest wounds and sores in domestic animals and man. Veterinary officers are being circularized for specimens of maggots, and the Pusa species have been under close observation for the last nine months. I have endeavoured to combine with the life-history observations an enquiry into the "chemotactic" reactions of the insects and of the parasites which evidently share them, but the chemical problems involved are such as require the assistance of a skilled biological chemist, who is unfortunately not available. The practical importance of an enquiry into these reactions is considerable, as a knowledge

of them would certainly simplify preventive and antiseptic measures.

(2) Energetic relations of insects: their consumption and economy of chemical energy under varying conditions. Mr. S. K. Sen is obtaining data for this investigation during my absence, in the form of food, oxygen, and water curves for the whole life-history of various insects. I hope subsequently to correlate this work with enzyme-investigations of the type recently carried out by Mr. Barnes at Lyallpur. Results of practical importance may or may not be obtained.

(3) The pure chemical substances responsible for the "chemotactic" reactions of the males of three species of fruit-fly have now been definitely and certainly ascertained. They are methyl-eugenol and iso-eugenol. Similar reactions in the case of a small Oscinid are produced by Isovaleric aldehyde. Analogous but not precisely similar cases are under observation.

The immediate practical value of this work is almost negligible; its ultimate value may be large, since it indicates the practical possibility of entirely new methods of insect-control. It is far and away the most important result yet achieved by the section.

IV. Miscellaneous.

(*a*) **Lice.** The lice of sheep and goats were investigated. A lime-sulphur spray or wash, followed by a spray of weak vinegar, was found to give excellent results. Internal administrations are being experimented with. On human lice the effect of extremely small quantities of mercury compounds was found to be very marked, though the way in which they act is obscure.

(*b*) **Bugs.** An attempt was made to elucidate the nature of the "biting-reflex" in the bed-bug. The enquiry proved difficult, but there were indications that the ventral

sense-organ was of importance; the work will be resumed at a later date.

(*c*) **Ticks.** *Ornithodorus savignyi*, a possible disease-carrier, is under observation.

(*d*) **Mosquitos.** A *Taeniorhynchus* and *Culex gelidus* have had their life-histories determined. Both are extremely troublesome to cattle, and *C. gelidus* breeds normally or very frequently in cow's urine.

The breeding-places of mosquitos in Pusa were carefully mapped in March, and some time later the Director gave facilities for an anti-mosquito campaign on "control-breeding" lines. This has been successfully carried on and I hope that my absence on leave may have no appreciable effect on the success of an experiment which opened auspiciously.

With a view to determining the influence of local waters on mosquito-breeding, experiments were made on the effect of equimolecular salt solutions on the larvæ. The results were of interest as indicating that an unexpectedly high percentage of lime in water is to some species distinctly beneficial.

(*e*) **Fruit flies.** The Ber fly, *Carpomyia vesuviana*, and its parasites were under observation for the year, and the life-history of *Dacus longistylus* was worked out. An attempt to check a very severe infestation of peaches by *D. zonatus* at Lahore failed completely, the attack having gone too far to save the crop. Spraying operations must be started as soon as peaches are just on the point of becoming ripe.

(*f*) **Other Diptera.** Rice in the Balasore district was seriously affected by *Cecidomyia oryzæ* and other insects. I investigated the part played by Cecidomyia; but found that the greater damage was being done by non-dipterous insects, mainly the Rice Hopper, and Mr. Fletcher thereupon took over the work. The life-history of three horse-flies (*Tabanidæ*) has been worked out, as also that of the very

curious Diopsid fly *Sphyracephala hearseyana*, though the habits of the adult are still obscure. The early stages of acalyptrate muscoids breeding in mushrooms have been obtained, but it is not known how these species spend the dry and hot part of the year.

V. Collaboration.

The usual amount of identification work was carried on; the Indian Museum was supplied with a considerable number of specimens to assist in the compilation of the "Fauna of India."

I interviewed the Director of Fisheries, Bengal, with reference to larvicidal fish in connection with control-breeding schemes.

In connection with the Kathgodam Surra work, a "pre-rains" survey of the area has been made for bloodsucking flies; this will be correlated with a similar survey made during the actual Surra season. I inspected the area in company with Mr. Shilston.

Arrangements have been made to assist Mr. Ballard in a chemical investigation of the sexual reactions of *Amsacta*.

I attended the 2nd Science Congress at Madras, and was pleased to note the increasing strength and authority of the organization, and the generally high quality of the papers read.

VI. Programme of work for 1915-16.

The three lines of enquiry mentioned under the heading "Research" in the above report will be continued. In the event of my going on leave my assistants will carry on Nos. (1) and (2) until my return. Sanction has been requested for the publication of a book as projected in last year's programme.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration and Tours.

Charge. I held charge of this section during the whole year.

Establishment. Mr. J. H. Walton, the Supernumerary Agricultural Bacteriologist, was relieved of his duties to join his post in the Military Department on the 4th June 1915.

Mr. N. V. Joshi, the First Assistant, was on privilege leave for two months and 19 days with effect from 5th October 1914 and Mr. K. S. Vishwanatham acted for him.

Mr. Hardayal Singh, Assistant, was on privilege leave for one month and 12 days with effect from 19th August 1914.

Messrs. A. N. Bose and Hardayal Singh, assistants, were confirmed on the 26th May 1915 in their respective posts owing to the transfer of Mr. N. C. Basu to Bengal.

Tours. The following tours were made by me during the year 1914-15 :—

1. September 1914. To Calcutta to consult with the Excise Commissioner of Bengal, Bihar and Orissa and Assam on the subject of Bákhar and to investigate local conditions of rice beer distillation.
2. October 1914. To Shillong on Hill Recess.
3. November 1914. To Calcutta to interview Scientific officers of the Indian Tea Association and to inspect the Bengal Distillery Co.'s distillery at Konnagar.
4. March 1915. To Motipur and Peeprah Factory to arrange for carrying out manurial experiments with green manures.

II. Training.

Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, who was under training in this laboratory from 12th August 1912 to 13th August 1914, during the latter part of his training carried out an investigation on the bacteriological aspects of "Reh" soils from the Punjab and submitted a full and detailed report on this subject referred to below.

Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, was under training from 20th August 1914. Mr. Bal applied the method of biological analysis to samples of soils from Sind and carried out experiments in connection with the investigation of the action of bacteria upon nutrient matter in the soil and the occurrence of toxins in soils. He also isolated *Ps. campestris* from a specimen of diseased cabbage sent from Poona and from others locally obtained.

Mr. A. K. Bose, Assistant Chemist to the Indian Tea Association, Calcutta, worked in this laboratory from 13th February 1915. Mr. Bose was instructed in the method of biological analysis of soils and carried out experiments therewith on samples of soil from the Tea Districts as referred to in this report.

III. Soil Bacteriology.

Bacterio-toxins in soils. The work on bacterio-toxins in soils was continued and carried a stage further; it was found that the inhibition of nitrification occurring in soils under water-logged or semi-anaerobic conditions was not due merely to lack of the oxygen required for formation of the completely oxidized product, but to the action of toxins resulting from the activity of certain classes of bacteria which rapidly multiply under these conditions. That this toxic action was not due either to ammonia or carbon dioxide in excess was shown by the inhibitory action of water extracts of the toxic soil upon nitrification in normally aerated soil, and more conclusively by that of certain bacteria isolated from such soils, notably of one bacillus

(*Bacillus X*) the toxic action of which was found to be sufficient to interfere with the growth and activity of all other soil bacteria brought in contact with it or with its separated toxin in culture.

It was found that such toxins result from the decomposition of organic nitrogen compounds by bacterial action under semi-anaerobic conditions, and further proof that the inhibition of nitrification is not due merely to shortage of oxygen was afforded by the observation that, with the same air supply as was sufficient for complete nitrification of ammonium sulphate in soil, nitrification of oilcake containing the same amount of nitrogen was completely inhibited, nor did it commence when complete aeration was provided, until after the lapse of a considerable period (generally about two weeks although this varied with different soils) when the toxins formed had had time to become destroyed by oxidation, after which normal nitrification ensued. It was found in actual practice in the field that germination in a soil which had been water-logged was interfered with, and that the ensuing crop was consequently poor, nor was this remedied by application of nitrate of soda, although the use of superphosphate was successful. Laboratory experiments showed that rapid reduction of nitrate takes place in water-logged soil, a large proportion of nitrite being formed, and it seems probable that the toxins produced during the water-logged period would not only affect the germination and the growth of the seedlings but that the character of the soil complex resulting from the semi-anaerobic conditions which obtained at that time would be such as not only to interfere with nitrification but to promote reduction for just so long as this abnormal character persisted. The character of the soil complex and that of the decomposition products of organic matter resulting from its action must vary with alterations in moisture and oxygen content of the soil itself, and it is probable that the altered character may persist for some time after the special conditions which gave rise to it have disappeared. This point is under experimental

observation. It was found in the laboratory that superphosphate had a neutralizing action upon the toxicity to bacteria of extracts of certain soils and this was traced to the free acid; this result, however, was not sufficiently conclusive to allow of its use as a convincing explanation of the favourable action of superphosphate upon waterlogged soils, although this theory is supported by Meggitt's work in Assam, but will require further experimental investigation.

Ammonification proceeded at the normal rate in soil under semi-anaerobic conditions and was apparently not interfered with by the bacterio-toxins produced although the activity of such ammonifiers as *B. mycoides* is actually lowered by the presence of *Bacillus X.*; this latter organism does not appear to be universally present in soils; no concentration of ammonia above that in the aerated control was found nor was this gas given off by the anaerobic soil. The action of carbon dioxide in excess was eliminated by absorption with potash, as well as by the use of the soil extract as mentioned above.

A special experiment was made to test the action of the carbon dioxide formed in soil by bacterial action upon nitrification in that soil; under partially anaerobic conditions absorption of the carbon dioxide produced no effect upon nitrification in soil, either of oilcake or of ammonium sulphate; in this experiment, the observation was repeated that complete nitrification of ammonium sulphate took place under semi-anaerobic conditions in which no nitrification of oilcake occurred.

It appears therefore that in soils in which aeration is incomplete, as a consequence either of want of proper cultivation or of drainage, the decomposition of organic matter by such bacteria as thrive under these conditions will result in the production of toxins inhibitory of nitrification. It has also been shown that these toxins are destroyed by exposure to air and can be removed in water solution, so that the ordinary operations of tillage and drainage can prevent their accumulation.

Work with seedlings (wheat, oats, rice, indigo, maize, *dhaincha, jowar*), has shown that in high concentration, such as occurs in water-logged soils containing much organic matter, these toxins may directly affect growing plants especially seedlings, but this is an exceptional condition, whereas it appears probable that in normal fully aerated soils the toxins resulting from the ordinary metabolic activity of soil bacteria are oxidized at about the same rate as they are produced and no accumulation takes place. A very slight interference with the oxygen supply to the soil, however, will turn the scale in favour of accumulation of toxins and in consequence upset the natural equilibrium existing in the soil complex between the toxin-sensitive nitrifying organisms on the one hand and the apparently less easily affected reducing organisms on the other, thus resulting in indirect injury to the crop by interference with the supply of nitrogen as nitrate. In soil which has been flooded during the monsoon the toxins formed may persist long enough to seriously prejudice the growth of seedlings if planted too soon; such soil should be given as long a period of aeration as is possible before planting.

In order to ascertain the conditions under which such bacterio-toxins are produced in soils a great deal of work was carried out in isolating and determining the specific functions of soil bacteria, but the proper development of this line of enquiry would necessitate collaboration with a chemical specialist. The possible bacterial origin of the various organic compounds of a toxic nature which have been isolated from soils by such workers as Schreiner, Shorey, Skinner, Reid and others would be one of the problems involved. It was found that salts of some of the heavy metals such as copper had a decided influence in neutralizing the toxic action towards seedlings of extracts of soils kept under anaerobic conditions; precipitation of the copper as sulphide was prevented by the addition of potassium cyanide, these salts being present in very small quantities; (0·025—0·03 per cent. $CuSO_4$). It appears

probable that the discrepancies recorded between the observations of some workers upon the stimulating effect of such salts upon nitrification may be explained by reference to the fact that the cases in which contradictory results were reported were not comparable owing to the use of organic nitrogenous matter, from which toxins could have arisen, in one series, and ammonium sulphate in another.

An interesting case occurred in the field at Pusa in which the use of copper sulphate as a precautionary measure against attack by wire worms resulted in a large increase on the treated plot as compared with an untreated control although both were free from attack by wire worm.

It was found in the case of seedling maize and *jowar* grown in soil or sand and watered with extracts of soil made toxic by keeping the latter under semi-anaerobic conditions that the residual contents of the seed were attacked by bacteria which had multiplied as a consequence of the prevalence of such conditions and had been transferred with the toxic extracts; the result of this attack was the production of toxic putrefactive bodies in immediate contact with the seedling resulting in its death; this did not occur in presence of copper sulphate. Mr. Milligan, Imperial Agriculturist, who drew my attention to the abovementioned field result with copper sulphate, has pointed out the significance of this observation in connection with this case, and the importance of its bearing upon the vital question of successfully bringing a field crop through the initial stages of germination and growth especially in heavy soils. Experiments are being carried out to test the value of antiseptics in relation to the early stages of plant growth under varying soil conditions from this point of view.

The toxic action of nitrites upon growing plants was demonstrated both under sterile and ordinary conditions in water cultures.

Nitrification. Numerous experiments on nitrification in soils and solutions were carried out and much valuable information on the subject obtained. This was especially the case in connection with biological analysis of soils from

various parts of the country, carried out for the most part by Assistants of Provincial Agricultural Chemists undergoing training in this section. Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, made a valuable biological analysis of Reh Soils from that province showing that although such bacterial activities as are essential to nitrification are practically non-existent in Reh Soils, this condition is completely altered by washing out the excess of salt. Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, tested the nitrifying power and capacity of certain soils from Sind which had undergone differential treatment in the field; this was found to vary considerably as a consequence of treatment. Interesting differences in comparative immunity shown by the nitrifiers in these soils to the inhibitory effect of partial anaerobic conditions as compared with the nitrifying agents in Pusa soil were observed, nor was the addition of lime beneficial in this respect. Nitrification in tea soils from different districts was studied by Mr. A. K. Bose, Assistant to the Scientific Officer to the Indian Tea Association; here very marked differences in nitrifying power between different soils, were found with varying results from the application of lime, and varying optima for water. Further experience with the method of biological analysis of soils has shown its value in elucidating soil problems and has made it possible to reduce it to a simple set of concurrent experiments.

The observed influence of toxins upon nitrification has been referred to above.

Nitrate formation in field plots under different crops has been under observation; grass has been found entirely to prevent accumulation of nitrate in the soil in which it is growing; this would have some bearing upon the action of grasses upon fruit trees, as the absence of nitrates must mean either that nitrification is inhibited or that the grasses take up the nitrate as rapidly as it is formed, or that in grassed-soil reduction takes place at least as rapidly as oxidation.

The effect of various trees upon nitrification due to the fall of their leaves upon the ground was studied and considerable differences were observed.

The optimum amount of organic matter as oilcake containing 5 per cent. nitrogen for nitrification in Pusa soil was found to be about 1 per cent. of soil weight. At a concentration of 2 per cent. ammonia formation was so rapid as to result not only in inhibition of nitrification but in loss of nitrogen as ammonia gas; the free ammonia also brought organic matter into solution and made it necessary to abandon the use of the tintometer for estimation of nitrates and to use the aluminium reduction method, which was found more convenient and reliable for this particular purpose than the zinc-copper couple. Indications were obtained that the prejudicial effect of organic matter upon nitrification is in many cases due to the rapid multiplication of toxin-producing bacteria consequent on its presence.

The effect of temperature on nitrification in Pusa soil was tested, the optimum being found to be near 35° C.; no nitrate was formed at 40° C., nor did nitrification take place in soil which had been kept at 40° C., when its temperature was afterwards reduced to 30° C.; further work on this point is being carried out to determine the cause of this apparent lowering of the thermal death point.

A series of experiments was carried out to determine if possible for what reasons on adding as solids such bacterial food stuffs as oilcake or sugars, to a live soil, the evolution of carbon dioxide resulting from bacterial action should rise in rate for a few days but fall again rapidly to a minimum long before exhaustion of the food supplied could be called upon to account for such diminution in activity. Reasons were found for thinking that this result, invariably obtained when solid nutrients were added to soil, was due in part to auto-intoxication by the soil bacteria, and in part to the purely physical facts of the case, depending upon the ratio between the superficies and the cubic contents of the particles of organic matter involved, and the possible protection against solution by

bacterial enzymes afforded by the superficial layer of altered material resulting from their first attack. This argument was strengthened by the observation that in nutrient solutions the fall in rate of evolution of carbon dioxide is much less sudden than where solid particles are concerned. The rate of formation of carbon dioxide is materially affected by the size of particles supplied. Partial sterilization of the soil sufficient to eliminate protozoa does not remove this difference.

Green Manuring. Owing to the difficulty of obtaining even areas of land for field experiments on the farm, it was arranged to take in a comparatively small area of one acre adjoining the outside laboratory of this section; this was divided into 24 plots of equal size and experiments in triplicate laid out for the *kharif* and *rabi* crops of 1914-15; the first was merely a crop of *sanai* (*Crotalaria juncea*) over the whole area; this was applied as green manure, variations in the method of application and their effect upon the succeeding *rabi* crops, oats and tobacco, being studied. As was expected, however, unevenness in this area made it impossible to draw definite conclusions from the experiments as a whole although certain deductions could be made from individual cases; these will be dealt with in the current report on green manuring. Some of the more interesting conclusions were drawn from the use of *seeth* made from *sanai* (*Crotalaria juncea*) the utilization of which had been suggested owing to the difficulty in obtaining indigo *seeth* consequent upon the reduction of area under this crop. It was found that the *seeth water* used in making the *seeth* was roughly equal in manurial value to the *seeth* itself in the case of the *rabi* crop (oats), but that in the residual effect on the succeeding *kharif* crop (maize) the *seeth*, as was expected, proved greatly superior to the *seeth water*. In the case of two areas under tobacco, one with normal and the other with comparatively low moisture content in the cold weather the effect of *seeth* as compared with green manure (*sanai*) ploughed in, in the ordinary way, was greater in the dry area. The differences produced

by green manuring in the rate of ripening both of the oats and of the tobacco were very marked. The effect of superphosphate in conjunction with green manure on the *rabi* crop was marked in soil with good moisture, but inappreciable in plots where the water content was low and the soil itself poor. A large number of observations were made on the changes going on in *seeth* during and after fermentation; it was concluded that the value of this material as a manure depends upon numerous factors of which its nitrogen content is the principal; at the same time great differences in the results may be obtained by proper or improper methods of preparation and application, especially the latter, as large quantities of toxic bodies are produced as a result of the semi-anaerobic conditions obtaining during the early stages of its manufacture, and can totally inhibit root growth if allowed to remain in the soil, being specially injurious to plants in the seedling stage. The time of application appears to be more important than the manner of preparation although these should be interdependent. In the meantime it will be necessary to crop the plots for some time without individual treatment and gain some knowledge of the extent of local variations amongst them. This seems especially necessary in the case of green manuring experiments the results of which are not likely to become strikingly obvious as quantitative differences in the succeeding crop of such an order as to carry them indubitably beyond the range of experimental error.

Studies were made of the development of root nodules on various leguminous plants with special reference to the depth below the surface at which they are formed, the effect of variation in the soil upon their vertical position, and the relation between their development and the age of the plant. With regard to this last, in the case of sanhemp (*Crotalaria juncea*) it was clear that each nodule had its own life-history independent of that of the plant, forming, developing to maturity, and finally shrinking and drying up to an empty shell; cultures and sections from nodules at various stages showed coincident changes

in the conditions of the bacteria and bacteroidal tissue. Nodules in all these various stages of development could be found at the same time on the same plant. Indications were obtained that nodule formation did not take place at that soil level at which most vigorous root growth was found, but tended to occur chiefly where the ratio of air to water was higher than was consistent with maximum root development. A characteristic difference in the character of growth was observed between roots in clay and those in sand, with intermediate variation in mixtures of the two, and similar changes where the plants were grown in alternate layers of these soils. It was remarkable that even in pure sand, nodule development was restricted to a comparatively shallow surface layer very slightly deeper than that found in the case of pure clay.

Sporadic development of nodules, insignificant in number, occurred at deeper levels.

The most universally prevalent characteristic was the fact that at least 90 per cent. of the nodules present at any one time were found on, or very closely adjacent to, the main stem, this being apparently due partly to the fact that such nodules had a longer life than those formed on more distal portions of the root, showing indeed the specific morphological characters associated with their host, and also in part to the fact of this position being coincident with the conditions of aeration which appear to favour their growth. An alternative hypothesis might suggest the importation of the specific *radicicola* organism by the seed and its consequent occurrence in the soil only in the neighbourhood of the latter; this, however, does not appear a probable explanation in view of the indigenous character of the legumes under observation. The general suggestion would be that nodule formation took place more readily in the earliest stages of the growth of the plant owing to the lower power of resistance to bacterial invasion which the latter possesses at that time. Rootlets of a similar age but formed at a later period of growth appear to be less readily invaded.

Azotobacter. Mr. Walton completed the initial stages of his work on *Azotobacter* in Indian soils, the results of which are being published in a Memoir. The preliminary survey showed the occurrence of *Azotobacter* in Indian soils of widely divergent type and situation; the variations in the organism from different localities were not sufficient either in morphological or physiological character to suggest differences of species. Fixation of nitrogen and its increase in amount as a consequence of added carbohydrates was demonstrated in soils in the field. Further work was projected on the symbiotic relationships between *Azotobacter* and soil algæ, some evidence having been obtained of the widespread and highly important nature of this natural source of soil nitrogen, but this has been temporarily abandoned in consequence of the appointment of Mr. Walton to a commission in the Indian Army Reserve of Officers.

IV. Special Enquiries.

Fermentation Organisms. The work on Bákhar was made the subject of a Memoir which was submitted for publication in April. The relationships between the amylo ferments and the Saccharomycetes involved in this question are still being studied.

Yeasts of the cerevisiæ type severally characteristic of the fermentation of *mahua* and molasses were separated from wild types present and supplied for trial to various firms of distillers; no conclusive reports have been received so far, but in the present condition of this industry in India it seems unlikely that much progress will be made of the kind essential for success in Europe, owing to the lack of expert knowledge in the distilleries. The success of the fermentation appears to depend upon its rapidity and consequent comparative freedom from bacterial or other contamination, and this rapid fermentation itself depends upon the use of a large quantity of active yeast; it is therefore upon the successful production of the "mass culture" of yeast that efficiency depends and as the only

methods of effecting this, so far as I know, in India are merely wholesale imitations of European practice, it is not to be expected that total disregard of the very large differences in the conditions under which growth of the yeast takes place in such widely different climates, will lead to any high standard of efficiency. On the other hand, it does not appear probable that any great experience or technical knowledge should be required to make successful modifications and adaptations of European methods to Indian conditions, but some, at least, is essential.

Saltpetre. Experimental work was carried on during the year in order to obtain some knowledge of the biological factors involved in the production of saltpetre in the soils of Bihar. Information was sought for on the following points :—

(1) Why does this industry flourish in particular localities ?
(2) Could it be extended either in the places where it is already established or into other districts ?
(3) Could the methods of recovering the nitrate from the soil be made more efficient ?

The enquiry is still in an early stage, but it seems clear that the leading factors in determining the localities in which this industry can flourish are (1) a high percentage of lime in the soil, (2) suitable climatic conditions for (*a*) nitrification of organic matter, (*b*) accumulation of the nitrates formed.

These conditions are fulfilled in several districts throughout India including the Punjab and the United Provinces but it is in Bengal and especially in Bihar that they are most favourable. It has been ascertained that nitrification goes on during the monsoon in soils containing much nitrogenous organic matter such as occurs in the neighbourhood of villages, and that concentration of the nitrates formed is prevented by the rainfall which carries them down, and allows production to go on in the soil stratum in which conditions of food supply and aeration

favour bacterial action, which would, however, be interfered with by accumulation of nitrate beyond a certain concentration. Such a concentration is found in some of the saltpetre earth collected for extraction by the *nuniahs* and as it is of an order many times greater than that necessary to inhibit nitrification, it is clear that it has not been produced *in situ* by this process, but has been arrived at by the evaporation of weak solutions of nitrates from the soil surface either in the field or on the walls of houses.

The *nuniah* collects *nuni-mati* or saltpetre earth from haphazard sites selected with reference to the accumulations of nitrogen characteristic of village sites and cattle sheds; hence he is dependent on uncontrolled supplies of raw material and any expansion of the industry could only be effected either by introducing the *nuniah* into hitherto unexploited districts or by artificial nitrification of nitrogenous organic matter which would otherwise serve some other purpose. An attempt is now being made to discover the extent to which the carrying out of this latter alternative is feasible. Local enquiry has elicited the fact that the *nuniah* does not generally make his business pay until the second or third year, which he attributes to the fact that the amount of nitrate obtained directly by extraction from the earth collected in the neighbourhood is insufficient on the average to pay expenses, and it is only when the accumulation of residual earth (which after extraction is carefully stored) is sufficient in quantity or suitably matured for a second extraction, that paying quantities of saltpetre are obtained.

If this information proves to be reliable it is obvious that a great deal can be done for the industry simply by ensuring that the time spent in maturing the store of residual earth shall be employed to the best advantage, *i.e.*, that the optimum percentage of organic matter and moisture shall be present, that no leaching by rain takes place, and that nitrification shall not be interfered with by the addition of excessive quantities of salts in solution in the "mother liquor" remaining after concentration,

which it is the *nuniah's* practice to return to the heap of residual earth. This practice may be harmless or even valuable up to a point, after which it must tend to lower the rate of nitrification.

The addition of wood ashes is another practice which probably might be modified with advantage after examination. The addition of organic matter will no doubt prove the most likely source of possible improvement; experiments on this point on a considerable scale are in progress.

Potato Rot. The enquiry into this subject referred to in my report for 1913-14 was completed and a Memoir on the subject was submitted for publication. It was shown that the rotting of potato tubers in store was in many cases due to the action of bacteria common in Indian soils; the conditions under which such bacteria were able to attack the tubers were described and preventive measures recommended. The practice of storing tubers in sand as a protection against potato moth appears to be responsible for many cases of rot in consequence of the increased chances of moisture condensation due to the use of earth instead of sand or imperfect ventilation.

V. Programme of work for 1915-16.

Major Subjects.

(1) Nitrogen fixation by Azotobacter.

(2) Nitrification of organic matter; including conditions severally favourable to ammonification and nitrification.

(3) Green manuring with special reference to organisms responsible for breaking down of buried plant tissues and their conversion into humus, ammonia and nitrates.

Field experiments in green manuring will be carried out in the Bacteriological area attached to the outside laboratory.

(4) Activity of soil bacteria with regard to the rendering available of phosphates and other

mineral plant-foods. This subject will be studied with special reference to the fertilizing action of superphosphate in conjunction with green manures.

(5) Soil Toxins. Bacterio-toxins occurring in soils; their influence on nitrification and the conditions conducive to their formation and destruction; this study is especially connected with the practice of green manuring and the use of organic manures in badly drained soils.

(6) Study of conditions under which saltpetre is formed in Bihar soils.

(7) Biological analysis of soils; a further study of the best means of carrying out this method of investigating soil conditions; this subject forms a principal part of the training of students in this section, the earlier stages being especially designed to allow of familiarization with the methods of obtaining information as to the biological conditions in a soil without undergoing a course of training in purely bacteriological technique.

Minor Subjects.

Study of organisms connected with fermentation.
Such cases of bacterial disease of plants as may arise.

VI. Publications.

The following publications were issued during the year :—

(1) A New Nitrite-Forming Organism, by N. V. Joshi. *Mem. Dept. of Agri. in India, Bact. Ser.*, Vol. I, No. 3.

(2) An article on "Turf," by C. M. Hutchinson. *Agricultural Journal of India*, October 1914, Vol. IX, Part IV.

(3) Report on Agricultural Bacteriology for 1913-14 for the Board of Scientific Advice, by C. M. Hutchinson.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

G. A. Gammie.

I. Charge and Tours.

I held charge of the appointment throughout the year.

Tours. In October, I visited the United Provinces and toured with the Deputy Directors of Agriculture and Economic Botanist.

In November, I visited the Central Provinces and travelled with the Deputy Director of Agriculture and Economic Botanist.

In December, the special trials of Egyptian and other cottons were investigated at Gokak in the Southern Mahratta Country.

In January and February, I was in Gujerat with the Deputy Director of Agriculture working out the characteristics of certain local cottons.

In March, I was in the Southern Mahratta Country working out some details with the Deputy Director of Agriculture.

II. Cotton in the Provinces.

United Provinces. *Cawnpore.* Mr. Leake's No. 7 is *Gossypium indicum*, var. *Mollisoni*, according to me. This is highly reported on by the trade and it certainly looks very promising. Here the glabrous form of Upland Georgian cotton is known as Dharwar-American and the hairy leaved one as Cawnpore-American.

Conformably with our experience the latter is the more suitable to grow, as it is hardier than the smooth-leaved form, which is also peculiarly subject to insect attacks.

In Dr. Parr's Circle, the Cawnpore-American is surpassed by *Bhuri*, an acclimatized Upland from Chutia

Nagpur. The Cawnpore-American at Cawnpore and elsewhere was originally of many types, but Mr. Burt has now satisfactorily purified it. As the result of spinning trials the cotton is said to be slightly superior to Middling American in all respects except that it has a proportion of short fibres, a character which will probably be eliminated by the methods of selection now being carried on. An increase of 2 per cent. in the ginning percentage is also possible and desirable.

Kalai. Here Mr. Leake has a well-arranged farm for growing his types and selections on a fairly large scale. This farm will serve as a centre of distribution of a pure supply of seed of the following varieties :—

(1) A white-flowered indigenous cotton fit for the use of the eastern parts of the Provinces.

(2) No. 7 or the white-flowered *indicum* which is being successfully introduced into Bundelkhand.

(3) A red-flowered cross which will eventually replace the inferior but highly productive white-flowered cotton of this tract.

(4) A large bolled variety of smooth-leaved Upland from Persia. This is not promising and it will probably have to be abandoned.

I visited several localities in which Bhuri cotton is grown, in the company of Dr. Parr and I agree with him in thinking that it is quite suitable for this tract.

Cotton operations in the United Provinces can be summarized as follows :—

In Mr. Burt's Division. The introduction of Cawnpore-American into localities with good soil and irrigation; the extension of No. 7, throughout Bundelkhand; the introduction of an early-maturing variety for the eastern parts. This, at present, is being evolved by Mr. Leake.

In Dr. Parr's Division. The present extension of the white-flowered indigenous cotton in place of the prevalent

mixture. This he hopes to supplant in time with Mr. Leake's improved red-flowered cotton; the extension of *Bhuri* as a higher class cotton in the favourable localities; a possible improvement of one yellow-flowered indigenous cotton at least.

Distribution of improved seed. It is satisfactory to note that this has received careful attention and I approve of the method now being worked out by Dr. Parr in the Western Circle. In this there are a large number of spring wells, giving a discharge of from 8,000 to 20,000 gallons an hour. It has been shown that this water can be raised more cheaply by oil-engines and centrifugal pumps than by bullocks. As a result, a large number of *zamindars* and cultivators are putting down pumping plants on their wells. Government is assisting by giving *takavi* for this purpose. These installations are doing very useful work directly, that is, in pumping water cheaply. They are also going to prove extremely useful in facilitating the supply of improved seed introduced by the Department. I will confine my further remarks to the needs of the cotton crop. Many of these oil-engine owners are being induced to put down cotton gins. At present it is hoped that for every one hundred thousand acres of cotton grown, there will be about twenty-five oil-engines, each with a cotton gin attached. The oil-engines vary in size according to the amount of water in the wells and the depth of the water from the surface, but each will command on an average about fifty acres of cotton, that is to say, there will be twenty-five seed-farms each growing fifty acres of cotton or a total of 1,250 acres. The produce of this area will sow about 18,750 acres in the following year so that these seed farms will supply seed to the total area of one hundred thousand acres once in about five years. No hard and fast rule need be laid down. If it seems advisable to cover the area more often, many more centres where pumping installations are working, will be available. To supply the twenty-five seed farms or the total private seed-farm area of 1,250 acres, an area of eighty acres will be

required. This will be entirely under the control of the Agricultural Department.

The private seed-farms will gradually establish a reputation as suppliers of good seed. The crop will be grown, the ginning done and the seed supplied at first under some supervision from the Agricultural Department. But it is hoped that gradually supervision will become unnecessary and a private seed supply agency will grow up and relieve the Agricultural Department of what is at present one of its most onerous duties.

My assistant, Mr. Mankad, also independently visited the Provinces and furnished notes supplementary to my own. The types grown at Cawnpore under numbers are thus understood by us.

I. *G. obtusifolium*,
II. *G. herbaceum*,
III. *G. arboreum*,
IV. *G. indicum* (true) with yellow flowers,
V. *G. neglectum*, broad-lobed, yellow flowered (var. *Malvensis*),
VI. *G. neglectum*, broad-lobed, white-flowered, with branching habit,
VII. *G. neglectum*, broad-lobed, white-flowered (*G. indicum* var. *Mollisoni* according to us),
VIII. G. *neglectum*, narrow-lobed, with yellow flowers (var. *vera*),
IX. *G. neglectum*, narrow-lobed, white-flowered (var. *rosea*),
X. Assam or Kil cotton,
XI. G. *sanguineum*, with pink flowers.

The Economic Botanist has numerous crosses and one between *arboreum* and *Mollisoni* has been worked up to a field scale. His object is to produce, if possible, a type possessing the following characters:—(*a*) early maturity, (*b*) heavy outturn, (*c*) high ginning percentage, (*d*) superior quality of fibre, (*e*) cotton with naked seed. To achieve the last object he has selected a long fibred type of Chinese cotton which has naked seeds, and this is used for crossing.

Type VII comes to maturity early and gives an average outturn of 800 lb. seed cotton with a ginning percentage of 33 to 34 and staple averaging three-fourths of an inch.

The cross *arboreum* × *Mollisoni* gives an outturn of 600 lb. seed cotton, with a ginning percentage of 33 and staple of about three-fourths of an inch. This cross, which resembles *Sanguineum* in all respects, is now in its fifth year and it is intended to start distributing its seed.

At the Kalai Farm Type VII is grown on 35 acres.

The crosses put out are:—(*a*) *arboreum* × *roseum*, purified white-flowers; (*b*) *arboreum* × *roseum*, purified yellow-flowers, seventh generation; (*c*) *arboreum* × *roseum*, purified pink-flowers; (*d*) *arboreum* × *indicum* var. *Mollisoni* (Type VII), pink-flowers, narrow-lobed; (*e*) *arboreum* × *Mollisoni*, red-flowered, purified.

At Cawnpore, under Mr. Burt, Black Rattler and other fancy types of American cottons have been tried with fresh seeds obtained from America but so far they show no promise.

Bhuri seemed hardier and better in growth than Cawnpore-American and also higher in ginning percentage. The fibre of both, however, seemed weak.

On the seed farm *roseum* appeared more promising than either Type VII or Cawnpore-American.

At Aligarh, the white-flowered local cotton (*roseum*) seemed better than Type VII. This gives an average outturn of 800 lb. seed cotton, with a ginning percentage of 37 to 38. The cultivators in this Circle have been independently selecting white-flowered cotton seed. It is possible that in the future the whole of the cotton in the tract will consist solely of this.

The conclusions arrived at by Mr. Mankad are that (1) the local cottons are the same as those of Sind (a tract with which he is familiar), but *less hardy*. (2) Of the pure types, *indicum* var. *Mollisoni* and *roseum*, the former produces the better staple, but is poorer in ginning percentage, (34) the latter gives a very high ginning percentage and it

is hardier. (3) Of the crosses, *arboreum* × *Mollisoni* is promising. It resembles *sanguineum* in all respects. Mr. Mankad has not personally seen the Mooltan cotton but from samples of it received from Lyallpur, it appears to him that cotton of this cross is lacking in *colour* although it has a finer staple. Of the American types, Cawnpore-American and *Bhuri*, he does not think that either will really succeed in this tract.

Central Provinces. At Telinkheri Farm the most promising selection is a cross between *Bani* and *roseum*.

The selections of *roseum* vary in percentage from 41 to 43.

Cambodia seems to ripen too late for this tract.

Allen's Long Staple is not promising.

At Tharsa, there is a very well-grown plot of *roseum* and there is no particular reason why it should not do well in this locality. At Chhindwara, an Upland cotton has produced beautiful bolls in Mr. Lawrie's orchard and that gentleman has promised to save the seed and put it out on a large scale. At the Seoni Farm the cottons are early ripening *Chapra* and *Saugar*. They are most suited for this tract. They are also being grown to demonstrate the advantages of drilling over broadcasting which is the local method. It is to be hoped that the people will follow the excellent examples shown on this farm. The *kamdar* is a particularly intelligent man and has a very clear idea of the nature and value of the experiments under his charge. At Sindewahi, Cambodia and *roseum* are being tried under irrigation on *wardi* soil. This is the third year of the trial on a large scale. Last year, under irrigation and manuring, the crops were 1,000 lb. of Cambodia and 1,200 lb. of *roseum*. The cotton was of a good quality. So far the cultivators hesitate between the claims of rice and cotton. This is not really a cotton-growing tract and it would only partially replace rice in the event of cotton prices ruling high. Mr. Clouston has hopes of a cross between *deshi Lahore* and *roseum*. It is valued at $8\frac{1}{2}$ per

cent. more than Hinghanghat. *Roseum* everywhere is a strong competitor against *Bhuri*, which will be restricted ultimately to wilt-infected areas.

Cotton from the Sindewahi Farm was reported on as follows by Messrs. Tata and Sons of Bombay :—

Roseum. Compared with roseum grown on the Akola Farm, it is a little longer in staple and softer in feel, though the class is dull. Can spin up to 12's. Value Rs. 190 per candy or equal to the price of Akola cotton on the day.

Bani × *Deshi Lahore.* Seems to be a little better in staple than the same variety sent from the Akola Farm, though not so bright as the other. Can spin up to 22's and 24's. Value Rs. 240 per candy.

Cambodia. Compared with *bani* of the Akola Farm it is weaker in fibre and a bit shorter in staple. Can spin up to 30's. Value Rs. 260 per candy.

An analysis of these valuations based on the acreage outturn of seed cotton and percentage of cotton to seed shows that in actual values the three varieties from Sindewahi stand as follows :—

Roseum, Rs. 65 per acre.
Cambodia, Rs. 59 per acre.
Bani × *Deshi Lahore*, Rs. 40 per acre.

On the same basis nine varieties of cotton received from the Akola Farm stand as follows :—

	Per acre Rs.
(1) *Bani* × *Deshi Lahore*	58·14
(2) *Gossypium neglectum*, var. *rosea* . .	53·3
(3) *Gossypium neglectum*, var. *Cutchica* .	50·2
(4) *Gossypium neglectum*, var. *Malvensis* .	33·14
(5) *Gossypium hirsutum*, var. *Bhuri* . .	32·6
(6) *Gossypium neglectum*, var. *vera* . .	31·4
(7) *Gossypium indicum* (Bani) . . .	30·10
(8) *Gossypium neglectum* (Berar Jari) .	29·5
(9) *Gossypium neglectum* (Saugor Jari) .	26·13

Bombay: Southern Mahratta Country. After my visit to Gokak Agricultural station to inspect and report on some interesting experiments conducted by Mr. Kottur, I submitted the following note.

Egyptian cottons. In 1908-09, Abassi was grown. The plants were very vigorous and tall and gave good cotton. In 1909-10, the plants were stunted and were attacked by red-leaf blight. In 1910-11, Abassi and Meta-Fifi were both tried with seed procured from Sind. The plot became water-logged, the plants were attacked by red-leaf blight and the outturn was small. In 1912-13, the plants were moderate. This year they have done better. Mr. Kottur thinks that, by selection, he can finally make the cultivation of Egyptian cotton in Gokak a success and, as he is endowed with the spirit of independent research, I recommended that he should be encouraged to persevere. In this tract, cotton is grown under irrigation on four thousand acres out of an area of forty thousand acres, so in the event of success a large area could be put out under a high class cotton.

Cambodia cotton suffers from red-leaf blight. It gives a good yield under a low rainfall and a bad one under a heavy rainfall. The crosses from Nadiad-Abassi × Bourbon, Bourbon × Abassi, Abassi × Cambodia are not promising and they are becoming later in ripening. Broach cotton is only fairly satisfactory. Selected Kumpta does well. The local variety *kumpta* is the most to be depended upon under all conditions. Under irrigation it yields up to six hundred and seven hundred pounds of seed cotton per acre.

The following observations made by Mr. Kottur on Meta-Fifi sown from seed imported from Egypt by me are interesting as showing differences caused at once by a new environment :—

(1) The height of the plant, instead of being eight feet, is from four to five feet.

(2) Instead of bearing numerous long, upright, basal branches, it has none or very short ones.
(3) Instead of the fruiting branches being produced only above the middle of the plant they are produced from one-third the height of the plant upwards.
(4) The plants are glabrous.
(5) The teeth of the bracteoles, instead of being short, are long.
(6) The colour of the flower is light yellow and not bright lemon yellow.
(7) The length of the petals, instead of being two inches, is one and a half to one and three-quarters inch.
(8) The bolls in most cases are not well-filled, the tops being often blunt.
(9) The number of cells (locks) is three in all cases.
(10) The staple is one-half to one inch long.
(11) The covering of the seed varies. It is green-tufted at both ends, or only so at the tip; brown-tufted at both ends; brown-tufted at the tip only; and almost naked.

Although the seed was procured from a reliable source in Egypt it is quite probable that I may not have been supplied with the real article, and all the above differences may not arise from altered conditions.

The opinion of Messrs. Tata on a sample of Egyptian cotton from Gokak Farm is as follows:—

It is a long stapled excellent cotton having all the characteristics of Egyptian. We have no basis to value this cotton.

Broach cotton at Dharwar. There is now the eleventh generation of Broach. The percentage of cotton to seed has fallen to 29. The crop ripens almost as early as that of Kumpta. Mr. Kottur has detected eight different shapes of bolls in the Broach cotton. He is to sow the seeds from each of these separately so as to ascertain whether any differences will ultimately occur in ginning percentage and other factors.

There are four experiments being conducted on this farm in connection with Broach cotton :—

(1) *Shevri* (*Sesbania ægyptiaca*) and *jowar* used as wind-breaks. Owing to the absence of easterly winds this year the results are indefinite. As it has had effects on contiguous crops, *shevri* should be removed and the *jowar* alone kept on.

(2) To test the prevailing idea that *jowar* follows Kumpta more profitably than it does Broach. (Last year's conclusion served to prove that *jowar* follows Broach just as well as it does Kumpta.)

(3) Wilt disease. It has only appeared this year and is increasing in Broach cotton, especially in that from the new seed.

(4) Deep *versus* shallow ploughing.

Subsidiary tests are in progress to find out whether *jowar* sown in August will come on as quickly as that sown in July, the difficulty at present being that the cultivators say they cannot get their fields ready in July for sowing *jowar* after Broach cotton.

Very little of the Broach cotton produced by members of the Agricultural Association ranked as first class in the auction. They should not be discouraged by this failure but repeat the experiments in more carefully selected areas.

The members of the Association have also imbibed the idea that Broach has a bad effect on the succeeding *jowar* crop. The experiments on the farm (already referred to) may reassure them on this point.

Mr. Mankad has the following note on the sale of Broach cotton which took place on the 16th May 1915 at Dharwar :—

" In all, 39,000 lb. of seed were distributed covering an area of about 2,500 acres (10,000 lb. fresh seed imported from Navasari and 29,000 lb. from the special class of the auction sale of last year).

The cultivation of this cotton is chiefly confined to Dharwar, Hubli, Bankapur and Haveri Talukas of the Dharwar District and the Sampgaon Taluka of the Belgaum District.

Sowing took place in July as well as August. Heavy continuous rains spoiled especially the black soil area bordering Malad so much so that the crop had to be grubbed up and the area had to be put out under wheat. The shedding of the leaves was tremendous and the bolls dropped down; the opening was also unsatisfactory. The average yield in this area, *viz.*, the black soil area bordering Malad, was very disappointing—50 lb. per acre only.

In the eastern portion of the black soil area bordering Malad the yield per acre averaged 200 lb. *kapas*. The crop did not suffer much in these parts as the rains were not very heavy. The late rains in January and February were most unfavourable for all cotton crops and especially to Broach. The excessive moisture at that time induced the plants to throw out more of leafy and woody growth and the bolls already formed did not open at all.

Picking was very leafy. The local cotton Kumpta was also a six anna crop.

The total number of *dhokadas* of Broach cotton received at the Depôt was 1,274.

The cotton was graded in six classes according to ginning percentages and the following prices were obtained per *naga* of 1,344 lb. *kapas*:—

Class	Ginning per cent.	Price per *naga*
		Rs.
Special	*Nil*	*Nil*
1st	33·5	150
2nd	32·5	143
3rd	31·5	136
4th	30·5	127
5th	29·5	124
6th	Rejected Broach	110

The local cotton Kumpta on the day stood at Rs. 107 per *naga*.

In addition to Broach cotton 438 *dhokadas* of Kumpta cross having a ginning percentage of 27·5 and 26·5 got Rs. 110½ and Rs. 108½ respectively per *naga* of *kapas*.

The prices were offered from the point of ginning percentages. Broach cotton graded in Class IV was stronger and better in colour than that of Classes I and II.

The ginning percentage of Kumpta cross was very low this year owing perhaps to the deterioration of the variety due to local seeds being used every year. No seed was therefore bought back this year. Similarly the ginning percentage of Broach was low this year.

It will be seen from the statement that not even one *dhokada* has come in the special class. The number of *dhokadas* even in the first class was very small, *viz.*, 52.

All the Broach cotton was purchased by Mr. Jijibhai Ardeshiar Dewecha who was specially deputed by Messrs. Tata, Sons & Co., Bombay.

It is proposed to get about 3,000 lb. fresh seed from Navasari and to obtain all seed from the first class of the sale at 40 lb. a rupee (this will give about 10,000 lb.) so that in all there will be about 13,000 lb. for distribution this year. From the quantity of seed intended for distribution it seems that the area under Broach cotton will considerably fall this year."

Messrs. Tata make the following valuations and remarks on six samples sent from Dharwar :—

Serial No.	Name of Variety	Remarks
1	Kumpta from plot 608	No. 2 is in every respect superior to No. 1. No. 1 can spin up to 24's and No. 2 can spin up to 32's. Value No. 1, Rs. 230. No. 2, Rs. 245.
2	Kumpta selected for quality.	
3	Kumpta cross . .	No 3 is superior to No. 4—especially in strength of fibre. Can spin up to 24's. Value No. 3, Rs. 240 and No. 4, Rs. 235.
4	Kumpta × Ghogari	
5	Broach first generation	No. 5 is decidedly superior to No. 6. No. 6 has much deteriorated. No. 5 can spin 40's. Value Rs. 260. No. 6 can spin up to 30's. Value Rs. 240.
6	Broach 11th (last) .	

Basis of prices per candy of 784 lb. on 21st July 1915 :—

	Rs.
Kumpta (mixed)	210
Kumpta (pure)	230
Navasari	260
Surat	240
Broach	220
Saw-ginned	215
Cambodia	240
F. G. Mathia	160

By analysis of the market valuation and acreage on them these samples stand in the following order :—

	Value per acre Rs.	A.
(1) Kumpta Cross	61	9
(2) Kumpta selected for quality	56	3
(3) Broach (11th generation)	44	11
(4) Kumpta (from plot 608)	43	11
(5) Kumpta × Ghogari	40	9
(6) Broach (1st generation)	17	0

Exotic cottons at Gadag. *New Orleans*, imported from the United States of America, in 1908, does not differ now from Dharwar-American. The seed, at first naked, is now fuzzy.

Allen's Long Staple is coming down to the local percentage and Boyd's Prolific has changed in the same way.

Texas Long Staple is maintaining its percentage better.

Texas Long Staple and Allen's Hybrid are the best of the exotics at Gadag. They ought to be put to the test on a larger scale, as soon as possible.

Dickson, Peerless and Cook are also to be tried on a larger scale next season.

In alternate lines of Dharwar-American and Cambodia evidence of inter-crossing is apparent to the extent of one per cent. The belief is gaining ground that Cambodia is more suitable than Dharwar-American for dry areas.

Dharwar-American. New Orleans type comes true. It is later in ripening than the true Upland form. The staple seems better than that of Upland although the latter was valued more highly in the market.

The Upland has a ginning percentage of about 30, the New Orleans 28.

The Upland type is being grown pure in the Ranebennur Taluka by Mr. Kottur. The two varieties are grown mixed in Gadag and Ron Talukas.

The following is a note on the auctions drawn up by Mr. Mankad :—

"The auction sale of Cambodia *kapas* was held at Gadag on the 9th May 1915. In all 20,000 lb. of Cambodia seed were reserved for distribution purposes, 3,000 lb. from the Gadag Farm and the remaining 17,000 lb. from the purified lot of the special class of the auction sale of last year. Of this quantity, about 7,500 lb. to cover about 400 acres were sown in the Gadag and the Ron Talukas. The same quantity was intended for the villages of the Bijapur District, but on account of the suggestion made by the Government to put out larger areas under cereals, only half the quantity was distributed chiefly in the village of Kundergi in the Bagalkot Taluka and the villages of Mangoli and Muttigi along the Don river where the conditions seem more favourable. The area under Cambodia cotton in the Bijapur District will be roughly 200 acres.

Sowing was done from the end of September till the first week of October. On the whole the season was not unfavourable to Cambodia cotton in the Gadag and the Ron Talukas of the Dharwar District but it proved very unfavourable to the Dharwar-American. In the Bijapur District, however, the crop suffered on account of abnormally heavy rains.

With regard to the sowing period, it seems that Cambodia in the District thrives much better when sown in the beginning of October. The experience gained on the

Gadag Farm shows that Cambodia gives better results when sown in the middle of September. The Divisional Inspector of Agriculture has taken up this matter of finding out the right season for sowing as a special study.

The District Agricultural Officers during their tour in connection with the inspection of the corp have found Cambodia thriving much better in the village of Sudi in the Ron Taluka and in the villages of Kurtkoti and Hulkoti of the Gadag Taluka than in other places. The soil and other conditions do not materially differ and the comparatively poor progress of the Cambodia cotton in other places requires careful investigation.

The outturn per acre varied from 400 lb. to 100 lb. *kapas* with a ginning percentage from 32·5 to 37. In some well-cultivated fields at Sudi the yield was 600 lb. per acre, while the yield of Dharwar-American was not more than 500 lb. in any fields. Experience shows that Cambodia thrives in years when the rainfall is moderate.

I am strongly inclined to believe after examining the cotton that the staple of the Cambodia cotton has not only become weak but has considerably deteriorated in length also, *i.e.*, the staple is both weak and short. Unless selection work is undertaken, I am afraid that this cotton will lose its reputation. Experienced cultivators say that the cotton bolls are now becoming smaller in size than they were when the cotton was first introduced.

The varying results of Cambodia cotton would always be a strong factor against the possibility of its extension in larger areas; the extension will also remain limited, as the Dharwar-American cotton is very promising in the Ranebennur Taluka and the adjacent parts.

All the *kapas* was not received at the auction depôt, as the needy cultivators cannot wait till the auction sale is arranged for.

In all 1,189 *dhokadas* (4 Dhokadas = 1 Naga = 1,344 lb.) were received at the depôt. The cotton was graded in six classes according to the ginning percentages.

The prices offered for each class are given below per *naga* of 1,344 lb. :—

Class	Ginning percentage	Price
		Rs.
Special . . .	37 and above .	154
1st	36·5 . . .	145
2nd	35·5 . . .	146
3rd	34·5 . . .	140
4th	33·5 . . .	140
5th	32·5 . . .	135
Unclassified . .	. . .	132

The price of Dharwar-American on the day was Rs. 108. The prices realized are mostly from the point of ginning percentage.

It is proposed to purchase all the seed of the special class at 36 lb. a rupee, and about 1,000 lb. will be available from the Gadag Farm; so that the total quantity available for distribution this year will be about 10,000 lb.

With regard to the prospects of Cambodia and Broach cottons in the Southern Division, it can be said that :—

The two varieties of cottons have not been well established, as yet. In some favourable seasons they give excellent yields, while in some, they yield less than the local Kumpta. In some years there is timely rain for sowing the Broach variety early in July, while in others, the sowing season is unfavourable either through insufficient or too much rainfall. Similarly heavy late rains spoil Cambodia crop. Besides, there is a belief that the Broach crop impoverishes the soil and the following crop of *jowar* becomes very poor.

The percentage of lint also varies according to the nature of the soil though the seed sown is of very superior quality. Notwithstanding the above adverse conditions, people have a tendency to sow Broach cotton at least on a small scale and this tendency is due to the high price ensured to them by holding an auction sale by the Department.

The present high rate given by merchants in the auction sale is for the following reasons :—

(*a*) A large quantity of Broach and Cambodia *kapas* is gathered at one place by the efforts of the Department;

(*b*) The *kapas* is graded and there is a sort of guarantee for the declared percentage of lint;

(*c*) There is some Departmental check over the cultivators not to adulterate the cotton with other inferior varieties.

When the auction sale is stopped, merchants will not have the facilities mentioned above and the mill-owners will not be induced to buy the *kapas* at such high rates. The only merchants on whom the Broach and Cambodia cotton growers will have to depend, will be the local middle men, who, when they understand that there would be no auction sale, would offer as low a price as possible.

The only solution to continue the cultivation of Broach and Cambodia cottons in the absence of auction sales by the Department would be either :—

(*a*) that the cultivators should gin their own *kapas* and sell the lint, or

(*b*) that some organized bodies like the Agricultural Associations or Co-operative Societies should take up the work of arranging the auction sales on the same lines as is done at present by the Department.

The former appears to me to be impracticable. As regards the latter, it is a question whether the Agricultural Association, Dharwar, can undertake this sort of work independently.

I understand that the holding of auction sales has been financially successful to the Department. Besides, the work brings the Departmental Officers in close touch with numerous cultivators and cotton merchants. The expert merchants and mill-agents consider that the Broach cotton grown at Dharwar is as good a cotton as that grown at

Navasari or sometimes better. They have all along been giving good prices to encourage the cultivation and are still ready to continue the same. In the last auction sale Mr. Jijibhoy Ardeshiar Dewecha, Manager, Swadeshi Mills, Bombay, expressed his opinion that the cotton was very good and he would be glad to buy up to 10,000 bales of such cotton grown in the Southern Division.

In conclusion, it seems highly desirable that, until the cultivation of these two cottons becomes permanent on an extended scale, the auction of these should be continued by the Department. Similarly the steady supply of good seed (a large quantity from Navasari) will also have to be undertaken annually by the Department."

Messrs. Tata have the following valuations and remarks on six samples of cotton from the Gadag Farm :—

Serial No.	Name of Variety	Remarks
1	Dharwar-American—New Orleans type.	Both are far superior to Ordinary Saw-ginned Dharwar especially in length and strength of fibre. They have retained some characteristics of American. No. 2 is weaker in fibre than No. 1.
2	Dharwar-American—Upland type.	No. 1 can spin up to 40's. Value Rs. 260. No. 2 can spin up to 30's. Value Rs. 245.
3	Dharwar-American Ordinary.	It is ordinary saw-ginned. Can spin up to 20's. Value Rs. 215.
4	Cambodia, saw-ginned	No. 4 is so nicely ginned that the staple does not seem to be cut as it ordinarily ought to appear. The length of staple almost equals that of No. 5, roller ginned. Can spin up to 32's. Value both Rs. 240.
5	Cambodia Double Roller-ginned.	
6	Christopher × Culpepper.	It is superior to Nos. 4 and 5 especially in strength of fibre. Can spin up to 40's. Value Rs. 260.

Bases of prices are the same as those given for the six samples of Dharwar above.

An analysis of the valuations and average outturn places the Gadag samples in the following order :—

	Per acre Rs.	A.
(1) Dharwar-American, New Orleans type .	33	4
(2) Christopher × Culpepper	31	9
(3) Dharwar-American, Ordinary . . .	29	2
(4) Dharwar-American, Upland type . .	22	6
(5) Cambodia, saw-ginned	19	8
(6) Cambodia, double roller ginned . .	19	8

Karkeli cotton. This was tested at Bhilvadi in the Tasgaon Taluka of the Satara District by the Inspector of Agriculture, Sholapur.

The outturn of seed cotton was 204 lb. The Inspector says that the outturn was poor owing to the want of rain at the time of sowing, and from heavy rain after sowing. The germination was hence not satisfactory. The ginning percentage was 30.

Messrs. Tata made the following remarks on a sample of this cotton :—" It seems to have deteriorated a little in length of staple. Can spin up to 32's. Value Rs. 210 (Karkeli of the day Rs. 215)."

An analysis of the outturn and value gives the crop a value of Rs. 16-5-0 per acre.

Cottons at the Agricultural College Farm, Poona. Three cotton varieties, Cambodia, Bhuri and Broach are being tested on this farm. The valuations of all are identical and Broach, although it yields the heaviest crop, is falling off in percentage.

Messrs. Tata report as follows on samples :—

1. Cambodia . . .	This cotton has somewhat deteriorated in length of staple. It is rather coarse in feel. In other respects it has retained its characteristics. Value Rs. 230 (Cambodia of the day at Rs. 240).
2. Bhuri . . .	Same as above but a little better in feel. Value Rs. 230.
3. Broach . . .	A little better than Fine Broach. Compared with Navasari grown in the District has deteriorated. Value Rs. 230 (Fine Broach of the day Rs. 220).

The value of the crops stands as follows :—

	Per acre Rs.	A.
(1) Broach	60	6
(2) Bhuri	50	9
(3) Cambodia	46	15

Gujerat. The selected cottons are being grown by villagers round Surat on about 400 acres. There appears to be a consensus of opinion that the selected cottons are really superior to the prevailing article.

The Superintendent of the Surat Farm says that prices fluctuate in different centres of the District and cotton grown in the north invariably fetches a lower price than that in the south. Cultivators gain by taking the trouble to cart their cotton to the centre offering the highest price.

Ghogari exists as an appreciable mixture in Broach but not in Surat cotton.

The Superintendent also emphasized the fact which is true, *viz.*, that the Surat District is peculiar in that its conditions do not suit any outside variety of cotton so that cultivators would lose if adulteration of seed occurred. So far as we see then, Surat and Navasari cotton will always be grown pure and if contamination appears in the marketed product, it must take place after it leaves the cultivator's hands.

The Superintendent also assures me that the bulk of the Surat and Navasari cottons is bought forward by agents from the Ahmedabad Mills before the Bombay traders appear on the scene and that all the Broach cotton of the Bombay market is really grown in the Broach District. The prices offered by the Ahmedabad merchants are in advance of those offered from Bombay. It might be as well for the Department to bring its improved cottons to the direct notice of the Ahmedabad mill owners.

In *ghogari* the seed is larger than that of *deshi* and the cotton is more adherent so that it is more difficult to gin. The fuzz is white, while that of *deshi* is brown.

As a result of an inspection of many fields of cotton in the Jambusar Taluka of Broach we found that *ghogari* was grown in a very pure state. The prevailing form is round bolled and only a few plants with pointed bolls were found. In the event of a seed farm being established here to improve *ghogari* cotton, distribution could be easily arranged, as the villagers would naturally accept seed which is even only a little better than their own. There is sufficient land in the close vicinity of Jambusar town alone to provide area for seed farm purposes.

In Vavli village the cultivators co-operate in having their cotton ginned under their own supervision so that they are certain of getting back their seed pure. The difference in yield of clean cotton in *ghogari* as against *Broach Deshi* is 14 per cent.

The point to be decided was whether the farm at Broach is suitable for the improvement work in *ghogari* or whether it could be done more efficiently at Jambusar. It is known that *ghogari* bolls open badly in the real black soil but on the Broach Farm, where the soil is intermediate in character, this drawback is not encountered. It is therefore quite practicable to effect the selection at Broach for the whole of the *ghogari* tract and villagers round Jambusar would, no doubt, willingly agree to grow pure *ghogari* for seed distribution.

There are four types of *ghogari* cotton to be tested :—

(1) The first and typical has a large, round boll, with a high percentage of lint, which clings tightly to the seed which has a white fuzz. This will probably be the form ultimately selected.

(2) The second is a large, pointed boll, and the lint does not cling so closely to the seed. The fibre is finer and the fuzz is *brown*.

(3) and (4) are small bolled equivalents of (1) and (2).

On account of its high ginning percentage, its proportion in *Broach Deshi* mixture is steadily increasing and it would be safe policy to see that the cultivators get a hold of the best *ghogari* that can be developed.

Surat. Of the four cottons sent for valuation from this centre, taking into consideration their outturns and ginning percentages, they stand in the following order :—

	Per acre Rs. A.
(1) Selection II—General . . .	58 12
(2) Selection I-A.	53 4
(3) 1027 A L F	50 6
(4) Surti Broach Local , , ,	46 11

These figures prove that any one of the three selections is considerably in advance of the ordinary local cotton (the last) and it would pay the cultivator to take them up.

Sisodra Plot. In the Sisodra plot two of the above named varieties again come in and the three stand in the following order:—

	Per acre Rs. A.
(1) 1027 A L F	36 11
(2) Selection I	30 5
(3) Local Sisodra	29 12

There must be some good reason for the discrepancy in the value of the cottons from this plot as compared with those from Surat. It is probable that the cotton from Billimora and Chikhli furnishes the best so called Navasari cotton and that the product from Navasari itself is not quite so good as this.

Broach Plot. We have already noticed that the prevailing form *ghogari* is round-bolled and that only a few plants have pointed bolls. It is interesting to find from the market valuations that the commoner form yields the better cotton.

Next season when we will have outturn results from the two types of *ghogari* we may be able to say definitely which is the more profitable to grow.

Nadiad Farm. The acreage value of the indigenous *lalio* is Rs. 85-9 against Rs. 77-12 in Cambodia. This goes to prove that in the long run the local cotton will pay the cultivator best.

Madras. Although not requested to do so, I have taken the liberty of obtaining the expert opinion of Messrs. Tata, of Bombay on the cottons grown in the Presidency, samples of which were supplied for museum purposes.

Four samples of *karanganni* were received from Koilpatti Agricultural Station, of which three were special strains. The price of Tinnevelly for the day being Rs. 235, the ordinary *karanganni* sample with the percentage of

cotton to seed of 24, was valued at Rs. 220; Company No. 1 with percentage 27, valued at Rs. 245; Company No. 2 with the percentage of 31, valued at Rs. 240; Company No. 3 with the percentage of 33, valued at Rs. 235 per candy of 784 lb. There has been an increase of 9 per cent. in the percentage and an increase of Rs. 25 in the price. If the acreage results had been supplied, we should have been in a position to give the actual value of the cotton produced per acre.

Pulichai cotton is so largely contaminated with Berar seed that it is valued at the same figure. Company No. 2 (*Karanganni*, special selection by Mr. Sampson from last year's crop) is valued at Rs. 248, Tinnevelly of the day standing at Rs. 235.

The Cambodia samples from Koilpatti and Coimbatore were valued a little below the price of good Cambodia in Bombay.

Samples of *uppam* from Koilpatti and Coimbatore are valued at Rs. 205, the ordinary market rate. Bourbon from Coimbatore is valued equal to Navasari cotton at Rs. 270 and *nadam* from Coimbatore stands equal to Westerns at Rs. 200.

With Westerns selling at Rs. 200 in Bombay, the sample from Hagari was valued at Rs. 215.

With Northerns standing at Rs. 210, white-seeded Northerns from Nandyal was valued at Rs. 230; black-seeded Northerns from the same place at Rs. 225.

Coconada standing at Rs. 210, Yerrapatti red was valued at Rs. 215 and Coconada red, Rs. 205 and white Coconada from Samalkota, at Rs. 215.

Messrs. Tata make the following valuations and remarks on these samples :—

Basis of prices per candy of 784 lb. on 11th August 1915 :—

Tinnevelly, Rs. 235 : Uppam, Rs. 205 : Westerns, Rs. 200 : Cambodia, Rs. 240 : Northerns, Rs. 210 : Navasari, Rs. 270 : Berar Jari (Akola), Rs. 200 : Coconada, Rs. 210.

Serial No.	Name of Variety	Remarks
1	Ordinary *Karanganni* .	Of these four samples, No. 2 is best, Nos. 3 and 4 are alike, but a little bit inferior to No. 2 in length of staple. No. 1 comes last, being short in staple. Nos. 2, 3, 4 can spin from 30's to 32's. No. 1 can spin up to 24's. Value No. 1, Rs. 220 ; No. 2, Rs. 245 ; No. 3, Rs. 240 ; No. 4, Rs. 235.
2	*Karanganni* Special type Company No. I.	
3	Do. Company No. II.	
4	Do. Company No. III	
5	*Pulichai cotton* . .	This resembles Akola cotton. It is a short staple cotton. Can spin up to 16's. Value Rs. 200.
6	Tinnevelly cotton .	It is a strong, silky, good staple cotton more or less equal to Nos. 3 and 4. Can spin up to 30's. It is not *Uppam* as it is supposed to be. Value Rs. 235.
7	*Company No. 2*—Special Selection.	This is more like No. 2 but more silky. Can spin up to 32's. Value Rs. 248.
8	Cambodia from Koilpatti.	No. 9 is a bit longer in staple than No. 8. Both are silky, long stapled cotton. The fibre is weak and therefore cannot spin more than 32's. Value Rs. 235 for each.
9	Cambodia from Coimbatore.	
10	*Uppam* from Koilpatti	Both are alike coarse, short stapled, No. 11 being a bit whiter in colour than No. 10. Value Rs. 205 for each. Can spin 12's to 14's.
11	*Uppam* from Coimbatore.	
12	Bourbon from Coimbatore.	It is a long stapled, silky cotton. Can spin up to 40's. Value Rs. 270.
13	*Nadam* from Coimbatore.	It is very variable in length of staple and may be valued at Rs. 200. Can spin up to 16's.
14	White-seeded Northerns from Nandyal.	Both are silky long stapled cotton and strong fibred. No. 14 being whiter than No. 15, which is Red, No. 14 may be valued at Rs. 230 and No. 15, Rs. 225. Can spin up to 32's.
15	Black do. do.	
16	Yerrapatti Red . .	This is softer in feel and a bit longer in staple than Red Coconada. More suitable for dyeing. Value Rs. 215. Can spin up to 20's.
17	Coconada Red . .	Both are red and white ordinary types of Coconada. The fibre is coarse and staple shorter than No. 16. Can spin up to 16's. Value No. 17 (Red), Rs. 205. Value No. 18, for its colour Rs. 215.
18	Coconada white from Samalkota.	
19	Westerns from Hagari .	For Westerns, the staple is very good, being very long. Can spin 24's. Value Rs. 215.

N.B.—All the counts given here apply to warp and not weft.

It will be seen that in the majority of instances, a distinct advance in the value of cotton has been gained by

selection and if only ginning percentages and acreage outturns had been available, a rigid estimate could have been framed of the actual value of all the cottons which have been examined.

Burma. Mr. McKerral reports as follows:—

"The cottons received from you were grown at the Agricultural Station at Tatkon, Yamethin District, Burma. The year was rather wet and the cotton crop in general on this farm was not very successful. None of the Indian short-lived cottons were a success and they did not appear to do as well as the Burmese 'Wa-gale' (*G. neglectum*), which was grown alongside of them. The same was true of the long-lived types and Broach cotton proved a complete failure, while Burmese 'Wa-gyi' (*G. obtusifolium*) gave a fairly good crop although it flowered late. I conclude that our best chances of improving cotton in Burma will be to undertake selection for yield and ginning percentage with the indigenous varieties. I have, however, retained small cultures of all the cottons sent by you.

"With regard to the Burmese cottons, it was found that 'Wa-gale' (*G. neglectum*) which is our short-lived kind, consists of three well-marked botanical types (1) a yellow-flowered type, (2) a white-flowered. This occurs in small proportion in the ordinary crop and appears to be the type called by you 'Avena,' (3) a type showing reddish coloration of the petioles, leaves, bracteoles, etc., and possessing a longer and finer staple than the other types. This was found in samples received from the Shan States and looked a promising type. Unfortunately, however, its ginning percentage has been found to be very small. The white-flowered type appears to have the highest ginning percentage and in

the case of one single plant this appeared to reach 40 per cent. The white-flowered variety is being separated from the yellow and a large number of single plant selections of all three kinds have been made. No markedly different types have been observed so far in 'Wa-gyi' (the long-lived Burma cotton) and the crop appears to be fairly uniform. Further observations, however, are being made this year."

As in former years, I have to thank Messrs. Tata, Sons & Co., for the trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

III. Programme of work for the year 1915-16.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

(2) The study of the behaviour of Bourbon, Bhuri, Cambodia and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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